

EOT Charles River Basin
Infrastructure Synchronization Project

FINAL REPORT
Volume I

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In Association With:

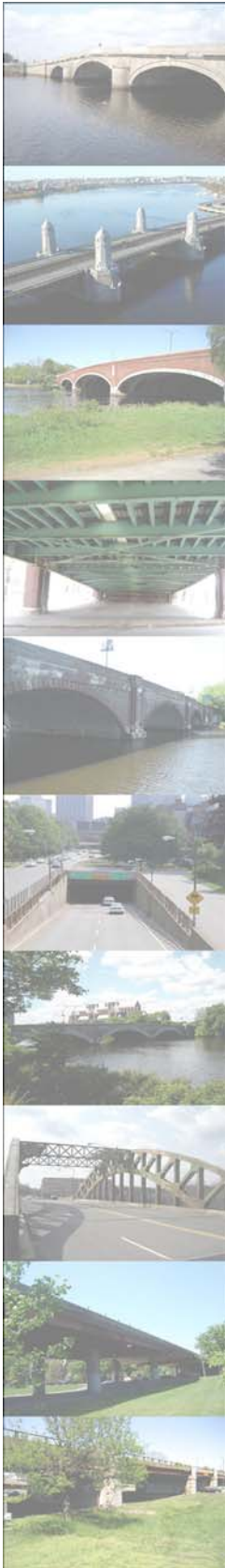
SIMPSON GUMPERTZ & HEGER





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Executive Summary

The transportation infrastructure within the Charles River Basin is entering a critical period in which many structures are simultaneously nearing the end of their expected useful service lives. The potential traffic congestion triggered by the myriad of lane restrictions and detours necessary to implement the appropriate rehabilitation programs threatens to disrupt the economy and vitality of Boston and surrounding communities. To address the situation, the Executive Office of Transportation and Public Works retained BETA Group, Inc. to study options for synchronizing the rehabilitation of twelve of these critical transportation assets over the next decade-and-a-half in a manner that would address public safety while minimizing impacts to traffic operations.

This Final Report presents a planning-level schedule for sequencing the rehabilitation of these twelve critical transportation assets. The sequencing of these projects, and the underlying analysis performed, strived to minimize traffic delays and congestion while maintaining public safety and convenience throughout the entire duration of the scheduled rehabilitation projects. The overall purpose of this Study is to utilize the schedule developed as an aid in scheduling design consultant procurement; determining required annual capital improvement funding; and monitoring and updating the schedule based upon the actual status, process, and duration of each individual rehabilitation project. In this way, changes in the overall schedule can be



reviewed to determine any resulting traffic implications such that they may be mitigated prior to them becoming an issue.

The results of this Study find that the synchronization schedule presented herein (Appendix A Figure A3) represents a logical sequence for the rehabilitation of these twelve structures while mitigating, to the extent possible, the anticipated traffic congestion. The resulting concurrent rehabilitation projects coupled with possible signal retiming and phasing found two time periods that exhibit the highest levels of unacceptable intersection level of service (LOS). These periods include a 30 month period commencing in 2012 in which two intersections will experience a level of service (LOS) F in the morning peak hour and two intersections will operate at an LOS E and one at LOS F during the afternoon peak hour. The second period is for a 12 month period commencing in 2015 where one intersection will operate at an LOS E and three at LOS F during the morning peak hour and two intersections will operate at an LOS E during the afternoon peak hour. Together these occurrences include seven intersections within the basin, of which four are located on Memorial Drive, two on Soldiers Field Road, and one on Massachusetts Avenue. From a global point of view, and an appreciation for the amount and magnitude of the construction underway during these periods, these results are remarkable. It is not expected that an alternate schedule depicting different or modified concurrent rehabilitation projects would result in improved intersection operations.

Also included in this Final Report are the methodology and processes used as a basis for the Study. Should the next phase of the



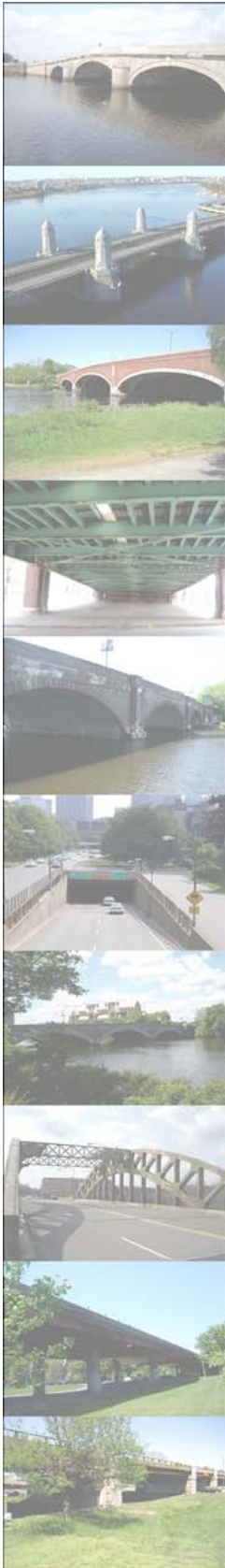
Study be implemented by EOT, some of the results obtained may be revised based upon different methodologies utilized to determine traffic re-assignment routes. In addition, as the results of the Study are presented to the stakeholders and public, additional information may be uncovered or presented. This information as well may have an influence over the results of this Study.



Study Purpose and Objective

In March 2008 BETA Group, Inc was retained by the Executive Office of Transportation and Public Works (EOT) to develop a comprehensive construction synchronization plan (the Study) for critical components of the transportation infrastructure in the Charles River Basin (the Basin). The objectives of the Study are to assess the current condition of the identified infrastructure assets, prioritize them by their impact to public safety and convenience, and develop a reasonable order and timing of the projects to minimize traffic and pedestrian disruptions. Only by looking at the entire transportation network in the Basin can the Study achieve an overall logical and workable solution.

The transportation network within the Charles River Basin encompasses numerous vehicular and pedestrian bridges and tunnel structures owned and maintained by the Department of Conservation and Recreation (DCR). Many of these structures are simultaneously nearing the end of their expected useful service lives and are in need of major rehabilitation efforts. Due to the advanced state of deterioration and concern to public safety, some of the structures are undergoing interim repairs in order to extend their useful service lives until a full rehabilitation program can be undertaken. Over the next decade-and-a-half, the transportation network within the Basin will be disrupted by these interim and full scale rehabilitation projects. With close to 450,000 vehicles using these structures daily it is imperative that a global plan for the Basin be developed to establish a logical sequence for the rehabilitation of these structures. This plan needs to consider public



safety, maintenance of traffic flow, and the management and mitigation of construction impacts in order to maintain the economy and vitality of Boston and surrounding communities.



Study Area

The Study encompasses the geographical area (see Appendix A Figure A1) along the Charles River bounded to the west by the Eliot Bridge, to the east by the Craigie Bridges (Route 28), to the south by the Massachusetts Turnpike (I-90), and to the north by Washington Street in Cambridge.

Infrastructure Assets

Within the study area, the following infrastructure assets have been identified by EOT and DCR as critical transportation structures to be included in the Study:

1. Boston University (BU) Bridge
2. Bowker Interchange – Ramp H (NB off-ramp to Storrow Dr. WB)
3. Bowker Interchange – Phase II
 - a. Main Line over Beacon Street and Commonwealth Avenue
 - b. Main Line over I90, RR and Ipswich Street
 - c. Off-Ramp to Commonwealth Avenue over Muddy River
 - d. Southbound On-Ramp from Storrow Drive EB
 - e. Southbound On-Ramp from Storrow Drive WB
 - f. Northbound Off-Ramp to Storrow Drive WB
 - g. Northbound Off-Ramp to Storrow Drive EB
 - h. Storrow Drive EB over Bowker Interchange On- and Off-Ramps
4. Cambridge Street (River Street)
5. Craigie Dam Bridge
6. Craigie Drawbridge
7. Eliot Bridge
8. North Harvard Street (Larz Anderson Bridge)
9. Longfellow Bridge
10. Memorial Drive over Brookline Street (Reid Overpass)
11. Storrow Drive Tunnel Eastbound Underpass
12. Storrow Drive Tunnel Berkley Street Underpass



13. Western Avenue Bridge

14. Memorial Drive – Phase II

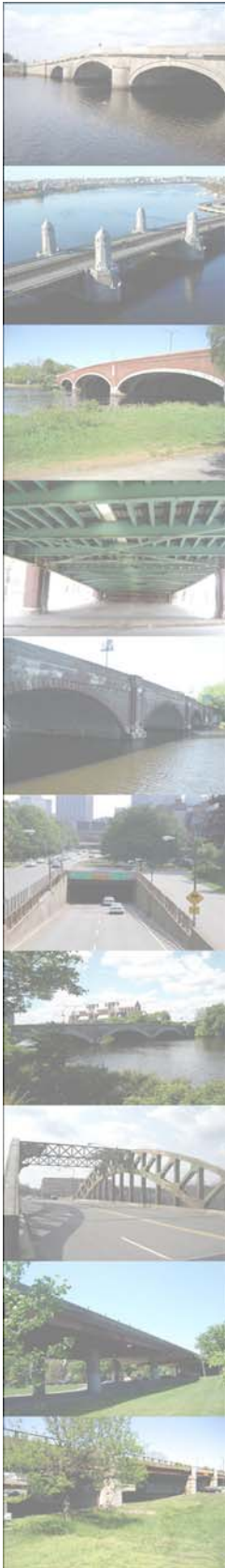
For the purposes of this Study, the structures that constitute the Bowker Interchange have been group together as one project identified as the Bowker Interchange – Phase II. The structure designated Ramp H, the Northbound Off-Ramp to Storrow Drive WB, is identified as a separate project because its rehabilitation has commenced with a recently-awarded construction contract.

Memorial Drive – Phase II is a proposed DCR roadway rehabilitation project extending along Memorial Drive between Massachusetts Avenue and Memorial Drive over the CSX Bridge. Although this proposed project does not encompass any bridge or tunnel structures, it will have a significant impact to traffic, and has therefore been included in the Study.

The list of structures included in Study is not an all inclusive list of the transportation structures in the Charles River Basin — only those structures deemed critical by EOT and DCR have been included.

Intersections

Within the Study area are numerous signalized and un-signalized intersections. For the purposes of this Study, forty-two intersections were identified as key locations (see Appendix A Table A-1 and Figure A2) from which to gauge the traffic flow and traffic conditions within the Study area. The majority of the identified locations are signalized intersections, while a small number are controlled via regulatory signing (i.e. stop, yield, or merge signs).



Study Methods

The Study has been divided into two phases in order to accommodate funding and schedule commitments. Phase 1 encompasses the Initial Study phase while Phase 2 encompasses the Final Study phase.

This Report presents the findings of Phase 1 which used the following methods:

- Review documents and information provided
- Develop traffic systems and models
- Screen and prioritize identified structures by relevant Study parameters
- Perform traffic management and level of service analysis for each individual project
- Determine occurrences of concurrent project constructions
- Superimpose traffic re-assignments for the identified project combinations
- Perform level of service analysis for the project combinations
- Review impacts to traffic operations as a result of project combinations and determine mitigation strategies
- Apply mitigation and re-run level of service analysis for the project combinations

The goal of the prioritization was to maximize the construction effectiveness while minimizing local and regional traffic impacts. The resulting synchronization Schedule (see Appendix A Figure A3) is based upon the expected durations of the permitting, design, and construction phases of each rehabilitation project. Potential delays due to outside forces, challenges, or funding were not accounted for in the Study.



Following is a discussion of the methods used in the Study to generate the synchronization Schedule.

Data Review

In order to gain an understanding of the existing conditions of the structures within the Basin, the Study included a review of available documentation provided by EOT, DCR, the Massachusetts Bay Transportation Authority (MBTA), and other outside sources. This documentation included:

- Design and as-built plans for each identified structure
- DCR Parkway Design Standards and Guidelines
- Bridge and tunnel inspection and load rating reports
- Progress prints of rehabilitation and repair plans currently in design, including staging and traffic management concepts
- Traffic studies and reports

A complete list of the documentation provided for the Study has been included in Appendix E.

Field Reconnaissance

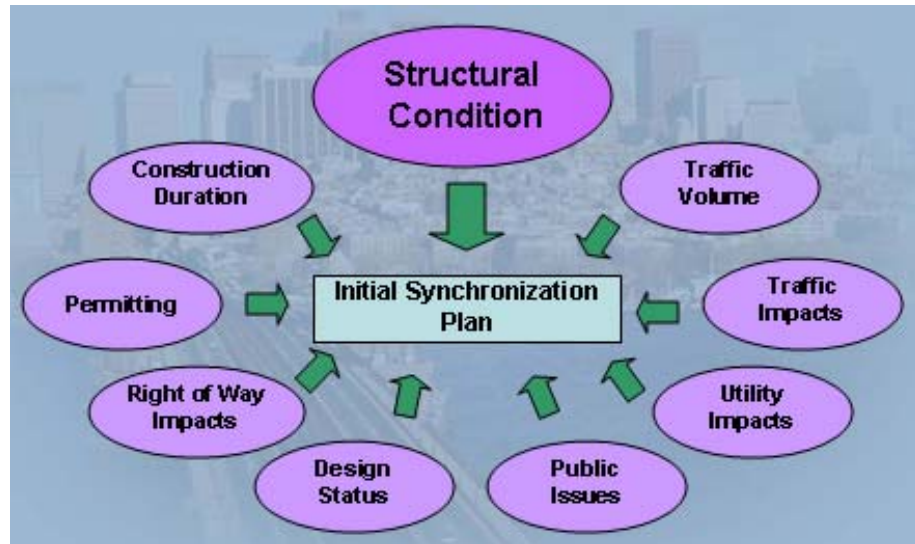
The BETA Team performed cursory visual field observations of each identified infrastructure site to review the general use and overall condition of the structure, visually confirm some of the information contained in the latest Inspection Reports, observe potential impacts to traffic patterns, identify potential staging areas, and review the overall constructability of the potential rehabilitation programs.

Initial Ranking

After the review of the available information and completion of the field reconnaissance, an initial ranking of the identified structures based upon the selected evaluation criteria was performed. The ranking was based, in



general, on the reported severity of each structure's condition; traffic volume; detour length; functional classification; current design status; and a qualitative review of ability, or inability, to be constructed concurrently with other structures. A matrix of the evaluation criteria is presented in Appendix G Table G-1.



The initial process resulted in the following order of construction for the identified structures.

1. Bowker Interchange – Ramp H (NB Off-Ramp to Storrow Dr. WB)
2. Craigie Dam Bridge and Craigie Drawbridge
3. Boston University (BU) Bridge
4. Longfellow Bridge
5. Cambridge Street (River Street)
6. Bowker Interchange – Phase II
7. Western Avenue
8. Storrow Drive Tunnels
9. Memorial Drive over Brookline Street (Reid Overpass)
10. Eliot Bridge
11. North Harvard Street (Larz Anderson)
12. Memorial Drive – Phase II



Although the Initial Prioritization and Decision Matrix presented in Table G-1 presents a summary of the evaluation criteria, not all of the criteria can be easily represented in such a tabular format. The additional criteria and other information used in addition to those found in Table G-1 are detailed below:

The rehabilitation contract for **Bowker Interchange – Ramp H** had been advertised for construction at the time the rankings were generated. Because no other project in the Basin was as advanced in the design process this structure was ranked first.

An assumption was made that Route 28 (**Craigie Dam Bridge** and **Craigie Drawbridge**) would serve as a logical alternate route to mitigate traffic delays during the construction of the Longfellow Bridge. At the time that the rankings were generated, the designs of the Craigie structures' rehabilitations were at the pre-25% stage, with a scheduled completion date of December 2008. In addition, DCR was in discussions with the US Coast Guard to obtain winter shutdowns (non-operational periods) of the drawbridge from November 1, 2009 to March 15, 2010 and again from November 1, 2010 to March 15, 2011 to accommodate the rehabilitation. Therefore, these structures were ranked second, with the additional assumption that they would be administered as one construction contract.

The design of the **BU Bridge** rehabilitation was at a 90% level of completion at the time the rankings were generated, with minimal permitting remaining. Because of perceived limited overlapping traffic impacts with the Bowker Interchange – Ramp H and Craigie Bridge



projects, the BU Bridge was ranked third. This ranking would allow the bridge's rehabilitation to be completed in advance of the need to use it as a detour route for other nearby projects.

The **Longfellow Bridge** rehabilitation was at the pre-25% design level at the time the rankings were generated; and there was a clear understanding of the required construction staging, extent of rehabilitation efforts and anticipated construction duration. Interim repairs are currently underway to strengthen the structural elements under the roadways. It was assumed that the full rehabilitation of the Longfellow Bridge and the Storrow Drive Tunnels cannot occur simultaneously. In addition, the planned interim repairs to the Storrow Drive Tunnels were designed with the assumption that the full rehabilitation program would commence within five years after the completion of the interim repairs. Therefore, the Longfellow Bridge was ranked fourth, with the goal of completing its rehabilitation before the commencing the full rehabilitation of the Storrow Drive Tunnels.

Cambridge Street (River Street), the Bowker Interchange – Phase II, and Western Avenue were ranked fifth, sixth, and seventh because of their overall structural condition in general, and because of the visual distress to the concrete elements and steel cross beams of the Bowker Interchange in particular. The rehabilitations of these structures were sequenced after the completion of the BU Bridge rehabilitation in order to avoid perceived overlapping traffic impacts with that project.

The **Storrow Drive Tunnels (Eastbound Underpass and the Berkley Street Underpass)** were ranked eighth. The interim repairs to



these structures currently underway are anticipated to extend the tunnels' service lives for an additional five years, at which point a full rehabilitation program must be undertaken. These two structures will be administered as one construction contract and rehabilitated simultaneously and as a result have been shown as one structure throughout this Report. The full rehabilitation of the tunnel structures should not commence until after the completion of the Longfellow Bridge rehabilitation and the majority of the Bowker Interchange – Phase II rehabilitation. It is anticipated that a minor amount of overlapping construction may occur between the Storrow Drive Tunnels and the Bowker Interchange – Phase II project.

Memorial Drive over Brookline Street (Reid Overpass) was ranked ninth because of the relatively good condition of its main structural elements in comparison to the other structures included in the Study. In addition, the rehabilitation projects for the BU Bridge and Cambridge Street (River Street) Bridges should ideally be completed prior to undertaking the Reid Overpass project.

The **Eliot Bridge** is in relatively good structural condition. The rehabilitation program is anticipated to be mostly cosmetic in nature. This structure was therefore ranked tenth.

The **Larz Anderson Bridge** was ranked eleventh due to its overall condition relative to the other structures included in the Study.

Memorial Drive – Phase II was ranked twelfth because of the non-critical nature of the roadway work envisioned, and the ability to



delay the start of this project until the completion of all other identified projects affecting traffic on Memorial Drive.

Structure Rehabilitation Plans / Staging

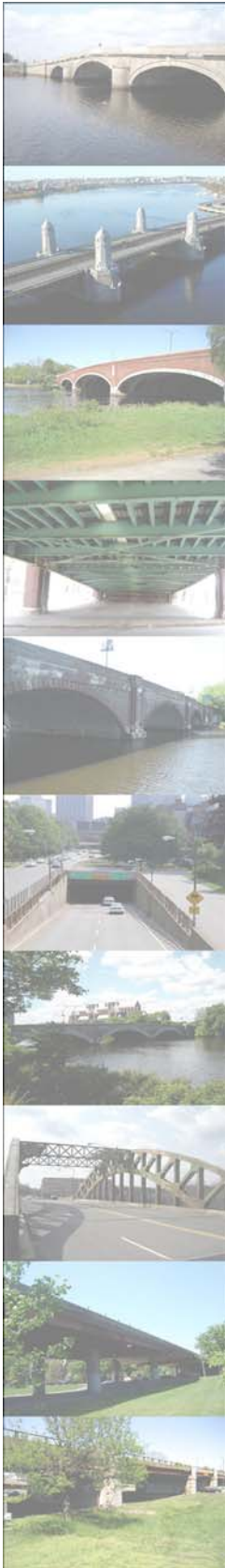
Of the twelve identified structures, five have rehabilitation projects actively in design. In-progress rehabilitation plans and construction staging schemes for these structures were therefore available for use in the Study. For the remainder of the identified structures, a probable approach for rehabilitation was developed in order to derive summary level construction staging. The developed staging concepts were utilized as a basis for determining anticipated traffic restrictions for each individual structure. These summary level staging concepts have been included in Appendix G as Figures G1 – G12.

Summary Condition Reports

Summary Condition Reports (Appendix K) for each identified structure were prepared based upon data obtained from existing inspection reports, load rating reports, plans, and other provided documentation. These reports provide summary level information regarding: the bridge owner and lead agency responsible for its rehabilitation; overall structural configuration; fracture critical elements; information on the structure's usage; numerical structural condition ratings; qualitative descriptions of main structural elements; utilities carried; probable rehabilitation plan; rehabilitation design status; a listing of the documentation reviewed; and a list of assumptions used in the Study.

Environmental Permitting

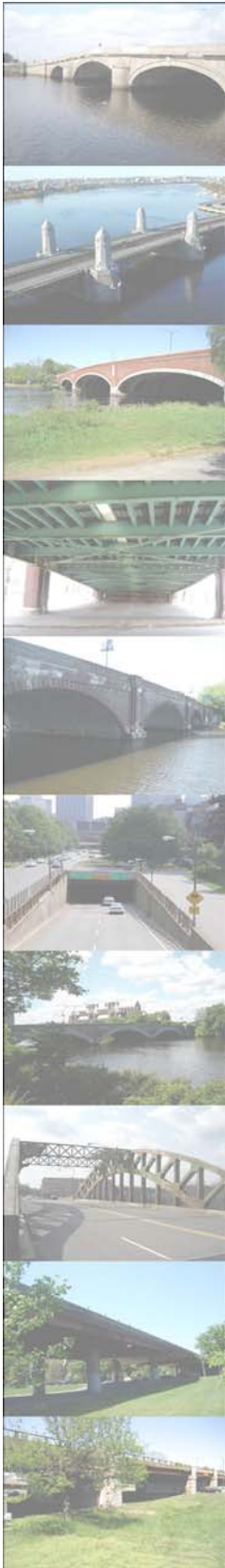
In support of the development of the synchronization Study, an assessment was performed in regards to the anticipated permitting



process required for each identified rehabilitation project. This assessment included a review of the probable rehabilitation programs and resulting construction tasks in order to determine which regulatory agencies would be involved and the resulting level of permitting review required. From this, an anticipated duration and timing for the permitting process was developed for each identified structure.

Because the environmental permitting process is an essential component to the success of rehabilitating the structures within the Basin, a Permit Briefing Meeting was held with EOT, DCR, MEPA, DCR, and DEP to discuss the potential environmental permits needed for the structures within the Study. Appendix L contains a complete breakdown of anticipated environmental permits, notifications, and reviews that may be required for each structure, as well as anticipated timeframes for the reviews and approvals. The following assumptions were used in the permitting assessment process:

- All structure rehabilitations will be federally-funded.
- All structures will include work or staging within a 100 foot wetland buffer and/or a 25 foot riverfront area, and will therefore fall under the jurisdiction of the Wetlands Protection Act (310 CMR 10.00). All projects will therefore require filings with the local Conservation Commissions (Boston, Cambridge, or both).
- In order to ensure that the permitting schedule does not impede the construction schedule, early coordination with federal, state, and local agencies will be a design requirement for all projects. Early coordination should begin at the initiation of project design.
- Most bridge work will require the use of barges in the Charles River for staging and access.



- All structures have been licensed by Chapter 91 or are exempt from licensing through legislative acts.



Traffic

This section presents the findings of the traffic analyses conducted to evaluate existing conditions, and the phase of construction for each synchronization project which is anticipated to have the most severe traffic impact.

Traffic Volume Data Collection

The Study utilized data gathered from a combination of historical and primary data collection sources. The primary sources consisted of peak hour intersection Turning Movement Counts (TMC) collected as part of the Storrow Drive Tunnel Reconstruction Project and daily roadway volumes collected by the Massachusetts Highway Department and provided by the Central Transportation Planning Staff (CTPS). A list of other data sources reviewed for the Study is included in Appendix E.

The peak hour traffic volumes on all structures crossing the Charles River between the Eliot Bridge and the Charlestown Bridge are included in Appendix F Figure F1. Peak hour turning movement volumes at the forty-two analyzed intersections are presented in Figures F2 – F5 in Appendix F.

Analysis Methods

Turning movement volumes, field sketches of intersection geometry, and observations of prevailing traffic conditions at all study area intersections were combined to develop existing traffic conditions. The SYNCHRO traffic analysis software (Version 6 Build 614) was used to develop morning peak hour and afternoon peak hour models. SYNCHRO implements the



analysis procedures for signalized and unsignalized intersections contained in the *2000 Highway Capacity Manual*.

Traffic operations are defined by level-of-service (LOS), which is a qualitative measure that associates LOS with vehicle delays. The criteria for signalized intersections are different than for unsignalized intersections because drivers expect different performance levels from each type of intersection. The relationship between LOS and delay is summarized in the following table:

LOS	Signalized Intersection Criteria Average Total Delay (Seconds per Vehicle)	Unsignalized Intersection Criteria Average Total Delay (Seconds per Vehicle)
A	< 10.0	< 10.0
B	10.1 to 20.0	10.1 to 15.0
C	20.1 to 35.0	15.1 to 25.0
D	35.1 to 55.0	25.1 to 35.0
E	55.1 to 80.0	35.1 to 50.0
F	> 80	> 50

Source: Highway Capacity Manual, Transportation Research Board; Washington, DC; 2000

Traffic volumes are expected to fluctuate as construction activities within the Charles River Basin commence, and are expected to increase commensurately along a few key segments of various roadways. These increased volumes often translate to a corresponding increase in vehicle delay and degradation of peak hour operations at the intersections along the roadway. Conversely, reduced traffic volumes are expected along other key segments. These reduced traffic volumes often translate to a corresponding reduction in vehicle delay and improvement in peak hour operations at the intersections along each affected roadway.



The study area intersections were initially analyzed for existing weekday morning and weekday afternoon peak hour conditions. The most severe construction stage for each synchronization project was selected for analysis. These analyses have assumed that no other synchronization projects will be occurring simultaneously. This information was utilized when looking at the resulting level of service under each combination in order to assess whether any degradation in level of service was due to an individual project, or as result of a combination of projects.

For consistency, all signalized intersection analyses were performed using existing traffic signal phasing and timing and have not been optimized to accommodate anticipated shifts in traffic patterns. The results for signalized intersection analyses are summarized in Tables I-1 and I-2 in Appendix I while the results for unsignalized intersections are summarized in Tables I-3 and I-4. This information is presented in a geographic format in Figure I1 in Appendix I.

Existing Traffic Conditions

Morning Peak Hour Analysis

Nearly all intersections included in the study area operate at LOS D or better during the peak hours under existing conditions. There are six signalized intersections which operate at LOS E or F during the morning peak hour. The following two signalized intersections operate at LOS E during the morning peak hour:

- River Street @ Memorial Drive,
- Columbia Street & Main Street @ Massachusetts Avenue,

The following four signalized intersections currently operate at LOS F during the morning peak hour:



- Memorial Drive @ JFK Street,
- O'Brien Highway @ Leverett Circle,
- Embankment Road eastbound @ Leverett Circle,
- Land Boulevard @ Monsignor O'Brien Highway

Afternoon Peak Hour Analysis

During the afternoon peak hour, twelve signalized intersections operate at LOS E or F. The following five signalized intersections operate at LOS E during the afternoon peak hour:

- Western Avenue @ Memorial Drive,
- Boston University Bridge @ Commonwealth Avenue,
- Beacon Street @ Berkeley Street,
- Beacon Street @ Arlington Street,
- O'Brien Highway @ Leverett Circle,

The following seven signalized intersections operate at LOS F during the afternoon peak hour:

- Memorial Drive @ JFK Street,
- River Street @ Memorial Drive,
- Boylston Street @ Massachusetts Avenue,
- Beacon Street @ Charles Street,
- Embankment Road eastbound @ Leverett Circle,
- Land Boulevard @ Monsignor O'Brien Highway,
- Causeway Street @ Commercial Street @ North Washington Street

The stop sign controlled northbound right turn from Memorial Drive onto the Longfellow Bridge operates at LOS E during the morning peak hour and LOS F during the afternoon peak hour. The southbound right turn from Memorial Drive to the Longfellow Bridge operates at LOS D and LOS C during the morning and afternoon peak hours, respectively. The southbound through movement at the unsignalized intersection of



the Longfellow Bridge and the Storrow Drive westbound Off-Ramp operates at LOS D during the morning peak hour and LOS C during the afternoon peak hour. The adjacent right turn operates at LOS C and LOS B in the morning and afternoon peak hours, respectively. The northbound right turns from Rutherford Avenue and Main Street onto Alford Street operate at LOS F during the morning and afternoon peak hours.

The higher number of intersections operating at LOS E or F during the afternoon peak hour is typical throughout the Boston area. This is in part due to elevated traffic volumes and in some cases elevated pedestrian volumes as well.

Construction Impacts

The following section will discuss the methodology and assumptions used to create construction impacts and analyze traffic operations for each synchronization project.

Traffic Reassignment Process

A traffic reassignment process was conducted for each project to account for traffic diversions due to construction. The process began by evaluating the volume of traffic currently passing through each project area during the morning and afternoon peak hours.

The proposed construction staging was then reviewed for each project. Details on the number and width of the travel lanes and any proposed intersection modifications to be implemented during each stage of construction were reviewed. The single construction stage anticipated to have the most severe traffic impact was selected for analysis. A construction period traffic link capacity was generated for each study project, and



the number of trips which would be likely to divert due to congestion was estimated.

BETA also obtained a set of “select-link” analyses for each study project from CTPS to aid in determining trip origins and destinations. These select-links provide trip origin and destination data for trips passing through a pre-specified roadway link in the regional transportation system. The CTPS model currently contains 2,727 analysis zones which represent the 101 cities and towns served by the Boston MPO. The 2,727 analysis zones were aggregated by CTPS into a more manageable 39 zones for use by BETA in this analysis (See Appendix M).

CTPS conducted a model run for each project, selecting a single “select link” in one travel direction. During each model run, origin and destination data were collected for each trip passing through the link in the specified direction during both the morning (6AM - 9AM) and the afternoon (3PM - 7PM) peak periods. The direction specified for each “select link” was inbound. It was assumed that the inbound direction would be reversed for outbound traffic. The results of the select-link analyses are located in Appendix M.

The select-link data and the volume of traffic expected to divert from a project area were used to generate reassignment routes. The reassignment routes generated for each study project are provided as Figures H1 through H12 in Appendix H.

Other assumptions include:

- Existing intersection level of service at intersections adjacent to a link were considered in the reassignment process.



- Reassignments were made primarily to collector and arterial roadways. Local / residential routes were not chosen for reassignments.
- In some cases, regional diversions were made to circumferential and radial highways including and within the I-95 belt.
- Secondary diversions (reactions to the initial reassignment process) have not been accounted for at this stage.
- Shifts in transportation mode have not been accounted for at this stage.

Traffic Capacity Assumptions

The following section will describe the assumptions made related to traffic capacity provided during the most severe traffic condition during each of the study projects.

Bowker Interchange (Ramp H): During the most severe traffic impact stage of construction the Bowker Line A to Storrow Drive WB will be closed. Line A traffic destined for Storrow Drive westbound would exit to the Charlesgate East surface road, continue along Charlesgate East to the intersection with Beacon Street, and take the Line A on-ramp to access Storrow Drive westbound. No physical improvements to capacity have been recommended by the traffic management plan for the intersections along the proposed detour route.

Craigie Dam Bridge and Drawbridge: The most severe traffic impact stage of construction would provide a single travel lane in each direction in the area of the Craigie Drawbridge. Since the two structures are closely spaced, traffic capacity restrictions imposed at one structure will effectively be imposed on the other. It was assumed that two-thirds of the inbound traffic and one-half of the outbound traffic would be diverted.



Reducing the inbound roadway to one lane significantly reduces the queuing space available on the approach to the traffic signals located at Leverett Circle.

Boston University (BU) Bridge: The traffic management plan proposes to provide one travel in each direction throughout the entire duration of construction. It was assumed that 50% of the traffic currently using the bridge would find an alternate route. This equates to a per lane flow rate of approximately 1,000 vehicles per hour per lane. This value would be low for an isolated lane, but in this case the traffic signals located at either end of the bridge control the volume of traffic which can flow over the bridge.

Longfellow Bridge: The construction stage anticipated to have the most adverse effect on traffic would provide two travel lanes in the inbound travel direction and one travel lane in the outbound direction. The two inbound lanes would not be side-by-side, but would be placed on either side of the MBTA red line tracks located in the center of the bridge. One inbound lane would remain on the inbound side of the bridge. The second lane would be diverted in Cambridge to a contra flow lane on the outbound side of the bridge, and it would terminate at a new signalized intersection in Boston. The new signalized intersection is currently an unsignalized intersection which serves outbound traffic to the bridge and existing traffic from Storrow Drive westbound. Inbound traffic traveling in the contra flow lane would be permitted to access the Storrow Drive eastbound on-ramp and Charles Street north of Charles Circle. It was assumed that approximately half of the traffic which currently travels in-



bound on the Longfellow Bridge and is destined for Storrow Drive eastbound or Charles Street north of Charles Circle would use the Contra Flow lane. All other movements would be served by the single lane on the inbound side of the bridge.

Cambridge Street (River Street): Throughout the construction period it is proposed that the existing three lane section be reduced to two lanes. As with other structures in the Basin, traffic flow on this structure is regulated by traffic signals on each end. The ability of the traffic signals to serve vehicles is reduced by the reduction in the number of lanes on the bridge. It was assumed that approximately one-third of the traffic currently using the bridge will choose to find an alternative route to reach their destination.

Bowker Interchange – Phase II: The stage of construction which is assumed to create the most severe traffic impacts is Phase 7, where the Line B Off-ramp and the Storrow Drive eastbound mainline are under construction simultaneously. During this stage the lane width of the Line B Off-ramp would be narrowed, and the Storrow Drive eastbound mainline would be reduced to one travel lane, reducing the traffic capacity of the mainline lane by approximately 50%.

Western Avenue: Throughout the construction period it is proposed that the existing three lane section be reduced to two lanes. As with other structures in the Basin, traffic flow on this structure is regulated by traffic signals on each end. The ability of the traffic signals to serve vehicles is reduced by the reduction in the number of lanes on the bridge. It was assumed that approximately one-third of the traffic cur-



rently using the bridge will choose to find an alternative route to reach their destination.

Storrow Drive Tunnels: Extensive traffic modeling was conducted by CTPS for the Storrow Drive Tunnels Reconstruction project. The information derived for the “Option A” construction period was used by this Study to represent the most severe traffic impact period. During this phase of construction two lanes of traffic would be maintained during peak hours. The eastbound Off-Ramp to Clarendon Street and the on-ramps from Berkeley Street would be closed to accommodate a temporary road for eastbound traffic which would pass through the Berkeley Street tunnel. An eastbound off-ramp to Dartmouth Street would be opened when the Clarendon Street off-ramp is closed. The westbound off-ramp to Arlington Street would also remain open during peak hours.

Memorial Drive over Brookline Street (Reid Overpass): Maintenance of eastbound traffic on the overpass is proposed for the duration of construction. When construction activities are taking place on the eastbound lanes, eastbound traffic would be shifted to the westbound lanes. Westbound traffic would be diverted to the Brookline Street surface rotary. Temporary traffic signals are proposed at two locations on the north side of the rotary to accommodate the increased traffic demand. When work on the eastbound roadway of the overpass is complete, eastbound traffic will resume travel in the eastbound lanes and the westbound lanes will be closed. It is assumed that no eastbound vehicles on Memorial Drive will choose to divert during construction activities. It is



assumed that 10% of Memorial Drive westbound traffic will choose to divert from the Brookline Street surface rotary to an alternate route.

Eliot Bridge: Two 11-foot wide traffic lanes are proposed for the duration of construction activity. This matches the number of lanes currently provided, but the lanes would be slightly narrower than the existing 12-foot lanes. It was assumed that 10% of traffic currently using the bridge would choose to use an alternate route to avoid the construction activities.

North Harvard Street (Larz Anderson Bridge): Throughout the construction period it is proposed that the existing four lane section be reduced to two lanes (one lane in each direction). As with other structures in the Basin, traffic flow on this structure is regulated by traffic signals on each end. The ability of the traffic signals to serve vehicles is reduced by the reduction in the number of lanes on the bridge. It was assumed that approximately one-half of the traffic currently using the bridge in each direction will choose to find an alternative route to reach their destination.

Memorial Drive (Phase II): It was assumed that construction activities associated with this project would be primarily confined to reduction of one lane at any time, which would maintain three open lanes at any one given time. Since traffic volumes through this area are directional in nature, a reversible lane traffic management strategy would be effective. This strategy would maintain two lanes eastbound and one lane westbound during the morning peak hour, and one eastbound lane and two westbound lanes during the afternoon peak hour. Utilizing this strat-



egy, all traffic in the primary direction could be accommodated, but a small percentage of traffic in the secondary direction would most likely seek an alternative route. It was assumed that 10% of westbound traffic would divert to an alternate route during the morning peak hour and 10% of eastbound traffic would divert to an alternate route during the afternoon peak hour.

Alternate Travel Routes & Trip Reassignment

The following section will describe the alternate routes for each structure on which diverted trips have been reassigned.

Bowker Interchange – Ramp H

All diverted trips have been reassigned to Charlesgate East as presented in the traffic management plan prepared for this project. Diverted traffic enters Storrow Drive westbound via the Line A on-ramp from Beacon Street.

Craigie Dam Bridge and Drawbridge

The results of the select-link analyses conducted for these structures are presented in Tables M-1 and M-2 located in Appendix M. Inbound traffic is generally originating in East Cambridge, Somerville, and areas along Route 28 north of the Craigie structures. A significant percentage of inbound traffic also originates in the Route 2 corridor and travels along Memorial Drive to Land Boulevard at the O'Brien Highway intersection. Inbound vehicles are generally destined for Downtown Boston, East Boston (including the airport), Back Bay, and areas along I-93 south of Boston.

The select-link analyses also indicate that outbound traffic on the Craigie Bridges generally originates along I-93 and Route 3 south of Bos-



ton, and in Downtown Boston and East Boston. These trips are generally destined for East Cambridge and Somerville.

Five primary routes have been developed to accommodate the origin-destination trends. The routes are presented in Figure H2, located in Appendix H. The routes divert inbound traffic from Memorial Drive, O'Brien Highway, and Gilmore Bridge to cross the Charles River via the Charlestown Bridge, the Longfellow Bridge, the Harvard Bridge, or the Eliot Bridge. Outbound traffic from Cambridge Street, Storrow Drive, and I-93 would also be diverted to the Charlestown Bridge, the Longfellow Bridge, the Harvard Bridge, or the Eliot Bridge; in addition these outbound trips would also be diverted to the I-93 Sullivan Square Exit. The percentage of diverted traffic expected to use each diversion route is presented in the following table:

Craigie Dam Bridge and Drawbridge				
Route	Percentage of Diverted Trips Using Route			
	AM		PM	
	Inbound	Outbound	Inbound	Outbound
Charlestown Bridge	30%	40%	20%	30%
Longfellow Bridge	15%	20%	20%	15%
Mass. Avenue	10%	10%	10%	10%
Storrow Drive	15%	10%	10%	15%
I-93	30%	20%	40%	30%

Boston University (BU) Bridge

The results of the select-link analyses conducted for these structures are presented in Tables M-3 and M-4 located in Appendix M. The analysis shows that inbound trips originate in East and Central Cambridge, and in the cities along I-93 located north of Boston. Inbound trips are destined for Brookline, Brighton, and areas along the Route 9 corridor located



within Route 128. The origin and destination trends for outbound trips are very similar to the inverse of the inbound trips (i.e. inbound origins are outbound destination, etc.).

A number of routes have been developed to accommodate the origin-destination trends, and are presented in Figure H3, located in Appendix H. Generally, trips are expected to divert to the Western Ave/River Street bridges, Massachusetts Avenue, the Longfellow Bridge, the Craigie Bridges, and to the Masspike and I-93.

The percentage of diverted traffic expected to use each diversion route is presented in the following table:

Boston University Bridge				
Route	Percentage of Diverted Trips Using Route			
	AM		PM	
	Inbound	Outbound	Inbound	Outbound
Larz Anderson Bridge	-	10%	-	10%
Western Avenue	25%	N/A	25%	N/A
River Street	N/A	20%	N/A	20%
Mass. Avenue	25%	20%	25%	20%
Longfellow Bridge	15%	15%	15%	15%
Craigie Dam Bridges	15%	15%	15%	15%
I-90	10%	10%	10%	10%
I-90 & Route 128	10%	10%	10%	10%

Longfellow Bridge

The results of the select-link analyses conducted for this structure is presented in Tables M-5 and M-6 located in Appendix M. The analysis shows that inbound trips are primarily originating in Cambridge, Somerville, and the areas along the Route 2 corridor. Inbound trips are generally destined for downtown Boston, Back Bay, and East Boston (including Logan Airport). Outbound trips are originating in East Boston, and the cities and



towns along I-93 and Route 3 south of Boston. Outbound trips are generally destined for Cambridge.

Four primary routes have been developed to accommodate the origin-destination trends. The routes are presented in Figure H4, located in Appendix H, and include diversions to the Craigie Bridges, Massachusetts Avenue, Storrow Drive (Eliot Bridge), and the Western Avenue and River Street Bridges.

The percentage of reassigned traffic expected to use each diversion route is presented in the following table:

Longfellow Bridge				
Route	Percentage of Diverted Trips Using Route			
	AM		PM	
	Inbound	Outbound	Inbound	Outbound
Storrow Drive	25%	-	-	25%
Craigie Dam Bridges	50%	40%	40%	50%
Mass. Avenue	25%	40%	40%	25%
River Street	N/A	20%	N/A	-
Western Avenue	-	N/A	20%	N/A

Cambridge Street (River Street)

The results of the select-link analyses conducted for this structure are presented in Tables M-7 and M-8 located in Appendix M. The results show that trips originate primarily along the Massachusetts Turnpike with smaller percentages originating in the Alston and Brighton neighborhoods of Boston. Trips are destined for Cambridge and Somerville.

Three primary routes have been developed to accommodate the origin-destination trends. The routes are presented in Figure H5, located in Appendix H, and include North Harvard Street / Larz Anderson Bridge,



Commonwealth Avenues, and the Massachusetts Turnpike. The percentage of diverted traffic expected to use each diversion route is presented in the following table:

Cambridge Street (River Street) Bridge				
Route	Percentage of Diverted Trips Using Route			
	AM		PM	
	Inbound	Outbound	Inbound	Outbound
I-90	N/A	30%	N/A	30%
Larz Anderson Bridge	N/A	30%	N/A	30%
Brighton / Comm. Ave	N/A	40%	N/A	40%

Bowker Interchange - Phase II

Information collected through the Storrow Drive Origin-Destination (O-D) Survey was used to assess the origin and destination characteristics of trips using these facilities. The results of the O-D Survey results for the Storrow Drive eastbound mainline and the Bowker Interchange eastbound off-ramp from Storrow Drive are presented in Tables M-19 and M-20 located in Appendix M.

The O-D survey data show that a significant percentage of the trips using the eastbound off-ramp to the Bowker Interchange are originating in the area along Route 2, and that these trips are destined for the Fenway area of Boston. Trips using Storrow Drive eastbound, east of the Bowker Interchange off-ramps, are originating in the same areas as the Bowker off-ramp, but these trips are primarily destined for the Back Bay, Beacon Hill, and Downtown Boston.

Four primary routes have been developed to accommodate the origin-destination trends. The routes are presented in Figure H6, located in Appendix H, and include Memorial Drive, Commonwealth Avenue, the



Massachusetts Turnpike, and Beacon Street through Cambridge as diversion routes around the Bowker Interchange area. A small percentage is also expected to exit Storrow Drive to Charlesgate East and use the local roadway network below the Bowker Overpass to access Boylston Street or to re-enter Storrow Drive eastbound. The percentage of diverted traffic expected to use each diversion route is presented in the following table:

Bowker Interchange – Phase II				
Route	Percentage of Diverted Trips Using Route			
	AM		PM	
	Mainline	Line “B” on-ramp	Mainline	Line “B” on-ramp
I-90	10%	15%	10%	15%
BU Bridge	-	25%	-	25%
Mass. Avenue	20%	30%	20%	30%
Longfellow Bridge	20%	-	20%	-
Craigie Dam Bridges	20%	-	20%	-
Charlesgate West	10%	30%	10%	30%
Commonwealth Ave.	10%	-	10%	-
I-93	10%	-	10%	-

Western Avenue Bridge

The results of the select-link analyses conducted for this structure are presented in Tables M-9 and M-10 located in Appendix M. The results show that trips originate primarily in Cambridge and Somerville. Trips are destined for areas along the Massachusetts Turnpike with smaller percentages destined for the Alston and Brighton neighborhoods of Boston.

Four primary routes have been developed to accommodate the origin-destination trends. The routes are presented in Figure H7, located in Appendix H, and include the Boston University Bridge, Memorial Drive, Massachusetts Avenue, and Interstate 93. The percentage of diverted



traffic expected to use each diversion route is presented in the following table:

Western Avenue Bridge				
Route	Percentage of Diverted Trips Using Route			
	AM		PM	
	Inbound	Outbound	Inbound	Outbound
BU Bridge	30%	N/A	30%	N/A
Memorial Drive	20%	N/A	25%	N/A
I-93 to I-90	20%	N/A	20%	N/A
Mass. Ave to I-90	30%	N/A	25%	N/A

Storrow Drive Tunnels

Traffic reassignments generated by CTPS for the Storrow Drive Reconstruction Project have also been used in this project. Traffic volume changes expected during the construction period are presented in Figure H8 for the morning and afternoon peak period. These figures show that traffic is expected to increase on the Mass Turnpike, Memorial Drive, Beacon Street (west of Dartmouth Street), Commonwealth Avenue, the Bowker westbound on-ramp, and the loop around the Public Gardens (Boylston Street, Charles Street, Beacon Street, and the Storrow Drive eastbound on-ramp). Traffic volume changes are primarily due to the re-location of the Clarendon Street eastbound off-ramp to Dartmouth Street, and the closure of the Storrow Drive eastbound and westbound on-ramps from Berkeley Street.

Memorial Drive over Brookline Street (Reid Overpass)

The results of the select-link analyses conducted for this structure is presented in Tables M-11 and M-12 located in Appendix M. The analysis results show that westbound trips using this structure originate in East Cambridge, the area along I-93 north of Boston, and the area along Route



1 north of Boston. These trips have destinations within the area along the Masspike (both inside of Route 128 and outside of I-495), West Cambridge, and along the Route 2 corridor inside of I-495.

Three primary routes have been developed to accommodate the origin-destination trends. The routes are presented in Figure H9, located in Appendix H, and include the Longfellow Bridge and the Harvard Bridge to access Storrow Drive westbound as well as Massachusetts Avenue and Western Avenue to access Memorial Drive, Storrow Drive, and the Massachusetts Turnpike west of the project area. The percentage of diverted traffic expected to use each diversion route is presented in the following table:

Memorial Drive over Brookline Street (Reid Overpass)				
Route	Percentage of Diverted Trips Using Route			
	AM		PM	
	Inbound	Outbound	Inbound	Outbound
Western Avenue	-	40%	-	40%
Storrow Drive	-	40%	-	40%
Mass. Avenue	-	20%	-	20%

Eliot Bridge

The results of the select-link analyses conducted for this structure is presented in Tables M-13 and M-14 located in Appendix M. The analysis shows that trips utilizing this structure originate along the Route 2 corridor (both inside and outside of I-495) and along the Route 3 corridor north or Route 128. These trips have destinations within downtown Boston, the Back Bay and Beacon Hill, the Fenway area, and within South Boston.



Six primary routes have been developed to accommodate the origin-destination trends. The routes are presented in Figure H10, located in Appendix H. The routes utilizing I-93 and I-90 are intended to service longer distance trips which originate from the outer areas of the Route 2 and Route 3 corridors. The routes utilizing Massachusetts Avenue, Greenough Boulevard, Western Avenue and Memorial Drive are intended to serve shorter distance trips. A large percentage of traffic is not expected to divert during the construction period because two travel lanes are expected to remain open at all times in each direction. The percentage of diverted traffic expected to use each diversion route is presented in the following table:

Eliot Bridge				
Route	Percentage of Diverted Trips Using Route			
	AM		PM	
	Inbound	Outbound	Inbound	Outbound
Memorial Drive	20%	30%	20%	20%
Greenough Blvd.	20%	30%	10%	20%
I-90	30%	-	30%	30%
Mass. Avenue	10%	30%	10%	10%
Western Avenue	-	10%	-	-
I-93 & Route 128	20%	-	30%	20%

North Harvard Street (Larz Anderson) Bridge

The results of the select-link analyses conducted for this structure are presented in Tables M-15 and M-16 located in Appendix M. The results show that inbound trips originate primarily in Cambridge, Somerville, and areas along the Route 2 Corridor. Inbound trips are destined for the Alston, Brighton, and Fenway neighborhoods of Boston. Outbound trips originate in the Alston and Brighton Neighborhoods of Boston as well as



areas along the Route 9 corridor and have destinations in Cambridge and Somerville.

Four primary routes have been developed to accommodate the origin-destination trends. The routes are presented in Figure H11, located in Appendix H, and include the Eliot Bridge, Greenough Boulevard, Western Avenue, and Cambridge/River Street. The percentage of diverted traffic expected to use each diversion route is presented in the following table:

North Harvard Street (Larz Anderson) Bridge				
Route	Percentage of Diverted Trips Using Route			
	AM		PM	
	Inbound	Outbound	Inbound	Outbound
Eliot Bridge	30%	30%	30%	30%
Greenough Blvd	20%	20%	20%	20%
Western Avenue	50%	N/A	50%	N/A
Cambridge/River Street	N/A	50%	N/A	50%

Memorial Drive - Phase II

The results of the select-link analyses conducted for this project are presented in Tables M-17 and M-18 located in Appendix M. The analysis results show that morning outbound trips originate in East Cambridge, and the areas along I-93 and Route 1 north of Boston. These trips have destinations in the area along the Massachusetts Turnpike inside of Route 128, the Route 9 corridor within Route 128, and the area along I-95 outside of Route 128. The origins and destination trends reverse in the afternoon peak hour for eastbound traffic. A reversible lane configuration is proposed for this project, which would allow the predominant traffic direc-



tion to remain in its existing corridor, and only a small percentage of traffic in the minor direction are assumed to divert.

Five inbound routes and four outbound routes have been developed to accommodate the origin-destination trends. The routes are presented in Figure H12, located in Appendix H. During the morning peak hour, it is assumed that some westbound traffic would use Washington Street in Somerville and Prospect Street in Cambridge to access the Massachusetts Turnpike. Other trips would use the Craigie Bridges, or the Harvard Bridge to access Storrow Drive and the Massachusetts Turnpike. During the afternoon peak hour, most diverted trips are expected to use same routes as the morning but in the opposite direction. A small percentage has been assumed to stay on the Masspike to I-93 northbound. The percentage of diverted traffic expected to use each diversion route is presented in the following table:

Memorial Drive – Phase II				
Route	Percentage of Diverted Trips Using Route			
	AM		PM	
	Inbound	Outbound	Inbound	Outbound
River Street	-	N/A	40%	N/A
Western Avenue	N/A	50%	N/A	-
Storrow Drive	-	15%	20%	-
Brookline Street	-	-	30%	-
Masspike to I-93	-	10%	10%	-
Mass. Avenue	-	15%	-	-
Washington Street	-	10%	-	-

Traffic Analysis Results

The following discussion will present the intersection level of service analysis results for each individual synchronization project. Analysis re-



sults have been generated using the existing morning and afternoon analysis models. Changes in traffic volumes determined through the trip reassignment process were then made to the base volumes. Intersection changes such as lane and lane width reductions or traffic control changes that may occur during construction activities were also implemented in the models.

Traffic reassignments to alternative routes generally increase volumes and degrade traffic operations. In some cases, however, traffic diverted from locations reduces congestion and improves operations at those locations.

Complete analysis results are summarized in Figures I2 – I13 and in Tables I1 – I4, located in Appendix I. The discussion in this section, however, will focus on intersections which would experience significant reduction in traffic operations (to LOS D, E, or F) as a result of construction activity.

Bowker Interchange (Ramp H)

Level of service changes for this project are isolated to the local roadways below the Bowker Interchange, as Bowker Overpass traffic destined for Storrow Drive westbound would be diverted through these streets.

Morning Peak Hour

Level of service would significantly decrease at the intersection of Commonwealth Avenue eastbound at Charlesgate East. The increase in traffic volume would cause the level of service to decrease from LOS B to LOS F.

Afternoon Peak Hour

During the afternoon peak hour, the level of service would decrease significantly at the following three signalized intersections:



- Beacon Street at Charlesgate East (LOS B to LOS F)
- Commonwealth Avenue westbound at Charlesgate East (LOS C to LOS D)
- Commonwealth Avenue eastbound at Charlesgate East (LOS C to LOS F)

Craigie Dam Bridge and Drawbridge

Changes in level of service are generally located in the east end of the Charles River Basin close to the project area.

Morning Peak Hour

Level of service is not expected to decrease significantly at the signalized study area intersections. The level of service at the unsignalized northbound right turn movement from Memorial Drive onto the Longfellow Bridge would decrease from LOS E to LOS F and the unsignalized southbound right turn movement from Memorial Drive to the Longfellow Bridge would decrease from LOS D to LOS E during the morning peak hour.

Afternoon Peak Hour

The level of service is expected to decrease at the following two signalized intersections during the afternoon peak hour:

- Beacon Street at Massachusetts Avenue (LOS D to LOS E)
- Gilmore Bridge at the Rutherford Avenue southbound ramps (LOS D to LOS E)

Decreases in level of service are also expected on the following approaches to unsignalized intersections within the study area:

- Storrow Drive westbound off-ramp through movement at the intersection with the Longfellow Bridge outbound (LOS C to LOS D)



Boston University (BU) Bridge

A significant percentage of traffic was assumed to divert from the Boston University Bridge during the construction period. The central location of this structure permits a variety of alternate routes. Consequently decreases in level of service are spread out over most of the study area.

Morning Peak Hour

Significant decreases in level of service are expected at the following four signalized intersections during the morning peak hour:

- Cambridge Street at the Masspike Ramps (LOS D to LOS E)
- River Street at Memorial Drive (LOS E to LOS F)
- Commonwealth Avenue at Brookline Avenue (LOS D to LOS E)
- Longfellow Bridge inbound at Charles Street (LOS D to LOS E)

Decreases in level of service are also expected on the following approaches to unsignalized intersections within the study area:

- Northbound right turn movement from Memorial Drive onto the Longfellow Bridge (LOS E to LOS F)
- Southbound right turn movement from Memorial Drive to the Longfellow Bridge (LOS D to LOS E)
- Storrow Drive westbound off-ramp through movement at the intersection with the Longfellow Bridge outbound (LOS D to LOS E)

Afternoon Peak Hour

During the afternoon peak hour, level of service is expected to decrease at the following five signalized intersections:

- Western Avenue at Memorial Drive (LOS E to LOS F)
- Cambridge Street at Turnpike Ramps (LOS D to LOS E)
- Memorial Drive eastbound ramps at Massachusetts Avenue (LOS C to LOS E)
- Beacon Street at Massachusetts Avenue (LOS D to LOS F)
- O'Brien Highway at Leverett Circle (LOS E to LOS F)



Decreases in level of service are also expected on the approach to the following unsignalized intersection within the study area:

- Storrow Drive westbound off-ramp through movement at the intersection with the Longfellow Bridge outbound (LOS C to LOS E)

Longfellow Bridge

The inclusion of the inbound contra-flow lane serves to reduce the traffic impact caused by construction activities at the Longfellow Bridge.

Morning Peak Hour

No significant decreases in level of service are expected at intersections within the study area.

Afternoon Peak Hour

During the afternoon peak hour, level of service is expected to decrease at the following three signalized intersections:

- Cambridge Street at Soldiers Field Road eastbound on-ramp (LOS D to LOS E)
- Memorial Drive westbound ramps at Massachusetts Avenue (LOS C to LOS E)
- Beacon Street at Massachusetts Avenue (LOS D to LOS E)

Cambridge Street (River Street)

Decreases in level of service are primarily located in the central area of the Charles River Basin.

Morning Peak Hour

Level of service is expected to decrease significantly at the following four signalized intersections during the morning peak hour:

- Soldiers Field Road eastbound ramps at North Harvard Street (LOS C to LOS D)
- Western Avenue at Memorial Drive (LOS D to LOS E)
- River Street at Memorial Drive (LOS E to LOS F)



- Brookline Street Rotary at Boston University Bridge Outbound (LOS D to LOS E)

Afternoon Peak Hour

Level of service is expected to decrease significantly at the following signalized intersection during the afternoon peak hour:

- Memorial Drive eastbound ramps at Massachusetts Avenue (LOS C to LOS D)

Bowker Interchange (Phase II)

Significant reductions in level of service would primarily occur in the central area of the Charles River Basin during construction. The traffic analysis results show that this project is more disruptive to traffic during the morning peak hour than during the afternoon peak hour. This trend is due to the fact that both roadways affected by the most severe traffic impact stage of construction are inbound roadways and their peak traffic period is the morning peak hour. Therefore, more traffic would be diverted by this project during the morning peak hour than during the afternoon peak hour.

Morning Peak Hour

Level of service is expected to decrease at the following five signalized intersections during the morning peak hour:

- Western Avenue at Soldiers Field Road eastbound off-ramp (LOS C to LOS F)
- Western Avenue at Memorial Drive (LOS D to LOS F)
- Cambridge Street at Soldiers Field Road eastbound on-ramp (LOS C to LOS E)
- River Street at Memorial Drive (LOS E to LOS F)
- Memorial Dr eastbound ramps at Massachusetts Avenue (LOS B to LOS D)



Decreases in level of service are also expected on the following approaches to unsignalized intersections within the study area:

- Northbound right turn movement from Memorial Drive onto the Longfellow Bridge (LOS E to LOS F)

Afternoon Peak Hour

Level of service is expected to decrease at the following three signalized intersections during the afternoon peak hour:

- Western Avenue at Soldiers Field Road eastbound off-ramp (LOS C to LOS D)
- Cambridge Street at Soldiers Field Road eastbound on-ramp (LOS D to LOS F)
- Beacon Street at Massachusetts Avenue (LOS D to LOS E)

Decreases in level of service are also expected on the approach to the following unsignalized intersection within the study area:

- Storrow Drive westbound off-ramp through movement at the intersection with the Longfellow Bridge outbound (LOS C to LOS E)

Western Avenue Bridge

Decreases in level of service are primarily located in the central area of the Charles River Basin.

Morning Peak Hour

Level of service is expected to decrease significantly at the following two signalized intersections during the morning peak hour:

- River Street at Memorial Drive (LOS E to LOS F)
- Boston University Bridge at Commonwealth Avenue (LOS D to LOS E)

Afternoon Peak Hour

Level of service is expected to decrease significantly at the following four signalized intersections during the afternoon peak hour:



- Boston University Bridge at Commonwealth Avenue (LOS E to LOS F)
- Columbia Street and Main Street at Massachusetts Avenue (LOS C to LOS D)
- Memorial Drive westbound ramps at Massachusetts Avenue (LOS C to LOS E)
- Massachusetts Avenue at Beacon Street (LOS D to LOS E)

Storrow Drive Tunnels

Significant decreases in level of service are not isolated to one specific area, but are spread across throughout the study area.

Morning Peak Hour

The level of service is expected to decrease significantly at the following three signalized intersections during the morning peak hour:

- Cambridge Street at Turnpike Ramps (LOS D to LOS E)
- River Street at Memorial Drive (LOS E to LOS F)
- Beacon Street at Arlington Street (LOS C to LOS E)

Decreases in level of service are also expected on the following approaches to unsignalized intersections within the study area:

- Southbound right turn movement from Memorial Drive to the Longfellow Bridge (LOS D to LOS E)

Afternoon Peak Hour

The level of service is expected to decrease at the following five signalized intersections during the afternoon peak hour:

- Boston University Bridge at Brookline Street Rotary (LOS D to LOS F)
- Boston University Bridge at Commonwealth Avenue (LOS E to LOS F)
- Beacon Street at Massachusetts Avenue (LOS D to LOS E)
- Beacon Street at Arlington Street (LOS E to LOS F)



- Boylston Street at Arlington Street (LOS D to LOS F)

Decreases in level of service are also expected on the following approaches to unsignalized intersections within the study area:

- Storrow Drive westbound off-ramp through movement at the intersection with the Longfellow Bridge outbound (LOS C to LOS E)

Memorial Drive over Brookline Street (Reid Overpass)

Significant level of service reductions are not expected at study area intersections during the morning or afternoon peak hours.

Eliot Bridge

Significant reductions in level of service caused by this project would be primarily located within the central area of the Charles River Basin.

Morning Peak Hour

Significant level of service decreases are expected at the following two signalized intersections during the morning peak hour:

- Cambridge Street at the Turnpike Ramps (LOS D to LOS E)
- River Street at Memorial Drive (LOS E to LOS F)

Afternoon Peak Hour

During the afternoon peak hour, level of service would decrease at the following two signalized intersections:

- Memorial Drive westbound ramps at Massachusetts Avenue (LOS C to LOS D)
- Memorial Drive eastbound ramps at Massachusetts Avenue (LOS C to LOS D)

North Harvard Street (Larz Anderson) Bridge

Decreases in level of service are primarily located in the west area of the Charles River Basin.



Morning Peak Hour

Level of service is expected to decrease significantly at the following three signalized intersections during the morning peak hour:

- Western Avenue at Soldiers Field Road eastbound off-ramp (LOS C to LOS D)
- Cambridge Street at Turnpike Ramps (LOS D to LOS E)
- Cambridge Street at Soldiers Field Road EB on-ramp (LOS C to LOS D)

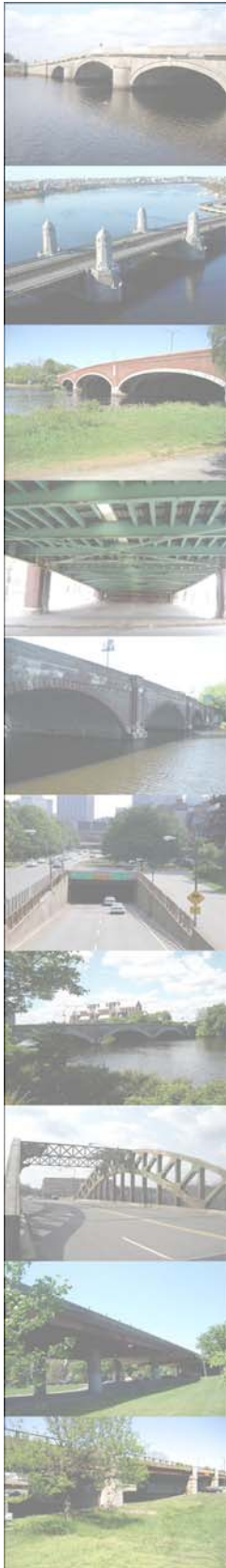
Afternoon Peak Hour

Level of service is expected to decrease significantly at the following two signalized intersections during the afternoon peak hour:

- Western Avenue at Soldiers Field Road eastbound off-ramp (LOS C to LOS D)
- Cambridge Street at Soldiers Field Road EB on-ramp (LOS D to LOS F)

Memorial Drive - Phase II

Significant level of service reductions are not expected at study area intersections during the morning or afternoon peak hours.



Concurrent Project Combinations

Thus far, projects have been analyzed on an individual basis to determine the potential effect each project would have on traffic operations within the Charles River Basin study area. The following section will focus on the effect of multiple projects occurring simultaneously.

Based upon the initial synchronization schedule (Figure D1 in Appendix D), the following combinations of concurrent projects were identified for analysis.

Combination 1

- Bowker Interchange – Ramp H (NB off-ramp to Storrow Dr. WB)
- Craigie Dam Bridge and Craigie Drawbridge
- Boston University (BU) Bridge

Combination 2

- Craigie Dam Bridge and Craigie Drawbridge
- Boston University (BU) Bridge

Combination 3

- Craigie Dam Bridge and Craigie Drawbridge
- Boston University (BU) Bridge
- Longfellow Bridge

Combination 4

- Boston University (BU) Bridge
- Longfellow Bridge

Combination 5

- Longfellow Bridge
- Cambridge Street (River Street)
- Bowker Interchange – Phase II
- Western Avenue

Combination 6

- Longfellow Bridge



Bowker Interchange – Phase II
Storrow Drive Tunnels

Combination 7

Bowker Interchange – Phase II
Storrow Drive Tunnels
Memorial Drive over Brookline Street (Reid Overpass)
Eliot Bridge
North Harvard Street (Larz Anderson)

Combination 8

Storrow Drive Tunnels
Memorial Drive over Brookline Street (Reid Overpass)
Eliot Bridge
North Harvard Street (Larz Anderson)

Combination 9

Longfellow Bridge
Bowker Interchange – Phase II
Western Avenue
Storrow Drive Tunnels

Combination Traffic Analysis Methods

Traffic volume reassignments for individual projects are the basis for developing traffic volumes for the project combinations. Individual traffic reassignments for each project included in a given combination have been added to the existing traffic volumes to describe traffic conditions during that combination.

Two time periods have been used to account for background traffic growth in the Charles River Basin. The two periods are:

Period 1 - 2007 to 2012

Period 2 - 2012 to 2017



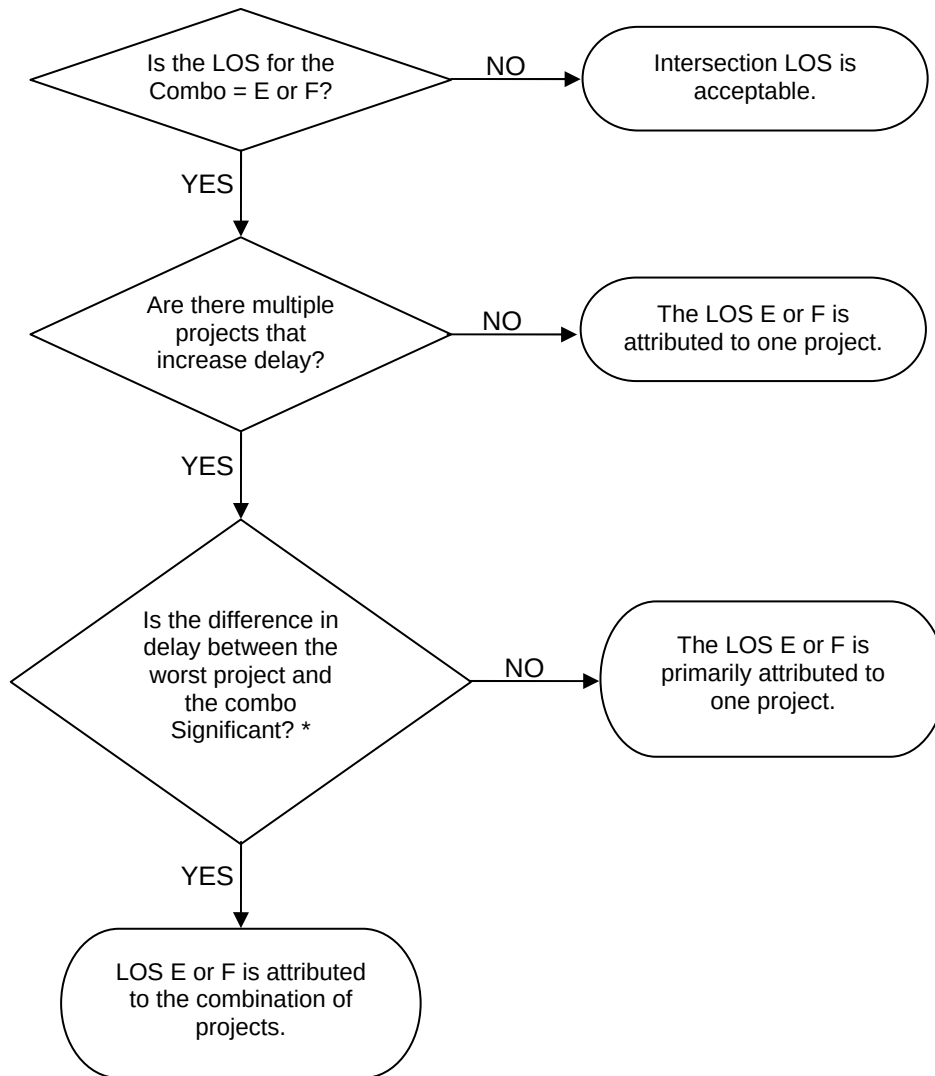
Combinations 1 through 4 occur during Analysis Period 1, and the remaining five combinations take place during Analysis Period 2. A traffic growth rate of 0.5% per year was developed to account for background traffic growth with the Charles River Basin. This growth rate was developed using regional trip tables supplied by CTPS. Only trips starting and ending in the traffic analysis zones within the Charles River Basin study area were used to calculate the growth rate. Traffic volumes for the combinations occurring in Analysis Period 1 have not been factored because of the likeness to existing conditions. Traffic volumes for combinations occurring in Analysis Period 2 have been factored by 0.5% per year compounded annually for 5 years to arrive at the year 2012.

The intersection geometry, signal timing and signal phasing used to evaluate existing conditions was used as a starting point to evaluate the project combinations. Where intersections were modified to reflect lane reductions, lane width reductions or traffic control changes in the individual projects these same changes were carried into the combination analysis for each project.

The results of the combination analysis are very much influenced by the nuances of the traffic reassignment performed for each individual project. One project could reduce traffic volume at an intersection while another project could increase traffic volume at the same intersection. It is also possible that all of the projects in a combination could increase traffic volumes at an intersection in varying degrees, which makes it difficult at times to determine if a level of service change is attributed to a single project or to the combination of projects. The following flow chart



presents a rigorous set of criteria which have been developed to determine if a reduction in intersection level of service is caused primarily by a single project or by the combination of projects.



* A significant difference in delay is approximately 12 seconds, which represents one-half of the range between LOS E and LOS F.

Combination Traffic Analysis Results

Complete analysis results for each combination are summarized in Figures D5 – D13 and in the tables located in Appendix D. The discussion in this section, however, will focus on intersections which



would experience significant reduction in traffic operations as a result of the project combinations.

Combination 1

Project Combination 1 includes three projects: Bowker Interchange - Ramp H, Craigie Dam Bridge and Drawbridge, and the Boston University Bridge. The analysis results for the morning and afternoon peak hours are as follows:

Morning Peak Hour

Level of service would be reduced from existing conditions at ten signalized intersections and two unsignalized intersections during the morning peak hour. Of the ten signalized intersections, five would operate at LOS E or LOS F. Both of the unsignalized intersection would operate at LOS F.

A comparison of the results of the combination analysis and the individual analysis shows that only one of the signalized intersections would operate at an unacceptable level of service due to the combination of projects. The intersection of Longfellow Bridge inbound and Charles Street would operate at LOS F during the morning peak hour primarily due to the increase in traffic from the Craigie Dam Bridges and Boston University Bridge projects.

One of the two unsignalized intersections would operate at an unacceptable level of service due to the combination of projects. The intersection of Longfellow Bridge inbound at the Memorial Drive ramps would operate at LOS F during the morning peak hour primarily due to the increase in traffic from the Craigie Dam Bridges and Boston University Bridge projects.



Afternoon Peak Hour

Level of service would be reduced from existing conditions at eleven signalized intersections during the afternoon peak hour, with nine of the eleven intersections operating at LOS E or LOS F. The following three signalized intersections would operate at LOS E or LOS F because of the combination of projects:

- Memorial Drive EB ramps at Massachusetts Avenue (LOS F)
- Beacon Street @ Massachusetts Avenue (LOS F)
- Longfellow Bridge Inbound at Charles Street (LOS E)

The level of service would be reduced to LOS E by the combination of projects at the unsignalized intersection of Longfellow Bridge outbound and the Storrow Drive westbound off-ramp. The intersection of the Longfellow Bridge inbound and the Memorial Drive ramps would operate at LOS F under existing conditions, but vehicle delay would increase significantly at this intersection due to the combination of the Craigie Dam Bridges and the Boston University Bridge projects.

Combination 2

Project Combination 2 includes two projects: Craigie Dam Bridge and Drawbridge, and the Boston University Bridge.

Morning Peak Hour

Level of service would be reduced from existing conditions at eight signalized intersections and two unsignalized intersections during the morning peak hour. Of the eight signalized intersections, four would operate at LOS E or LOS F. Both of the unsignalized intersection would operate at LOS F.



The analysis results show that only one of the signalized intersections would operate at an unacceptable level of service because of the combination of projects. The intersection of the Longfellow Bridge inbound roadway and Charles Street would operate at LOS F during the morning peak hour primarily due to the increase in traffic from the Craigie Dam Bridges and Boston University Bridge projects.

One of the two unsignalized intersections would operate at an unacceptable level of service because of the combination of projects. The Longfellow Bridge inbound roadway at the Memorial Drive ramps would operate at LOS F during the morning peak hour primarily due to the increase in traffic from the Craigie Dam Bridges and Boston University Bridge projects.

Afternoon Peak Hour

Level of service would be reduced at eight signalized intersections during the afternoon peak hour. Seven of the eight intersections would operate at LOS E or LOS F. The following three intersections would operate at unacceptable levels of service because of the combination of projects:

- Memorial Drive EB ramps at Massachusetts Avenue (LOS F)
- Beacon Street @ Massachusetts Avenue (LOS F)
- Longfellow Bridge inbound at Charles Street (LOS E)

Level of service would be reduced to LOS E by the combination of projects at the unsignalized intersection of Longfellow Bridge outbound at the Storrow Drive Westbound off-ramp. The intersection of Longfellow Bridge inbound and the Memorial Drive ramps operates at LOS F under



existing conditions, and vehicle delay would increase significantly at this intersection due to the combination of the Craigie Dam Bridges and the Boston University Bridge projects.

Combination 3

Project Combination 3 includes three projects: Craigie Dam Bridge and Drawbridge, the Boston University Bridge, and the Longfellow Bridge.

Morning Peak Hour

Level of Service would be reduced from existing conditions at six signalized intersections and two unsignalized intersections during the morning peak hour. Of the six signalized intersections, three would operate at LOS E or LOS F. One of the unsignalized intersections would operate at LOS E and the other would operate at LOS F.

The analysis results show that one of the signalized intersections would operate at an unacceptable level of service due to the combination of projects. The Memorial Drive EB Ramps at Massachusetts Avenue intersection would operate at LOS E during the morning peak hour because of the combination of projects.

The following two unsignalized intersections would operate at unacceptable levels of service due to the combination of projects:

- Longfellow Bridge inbound at Memorial Drive EB/WB Ramp (LOS F)
- Longfellow Bridge outbound at Memorial Drive WB Ramp (LOS F)

Afternoon Peak Hour

Level of Service would be reduced from existing conditions at twelve signalized intersections during the morning peak hour. Of the



twelve signalized intersections, seven intersections would operate at LOS E or LOS F.

The following two signalized intersections would operate at an unacceptable level of service because of the combination of projects:

- Memorial Drive EB Ramps at Massachusetts Avenue (LOS F)
- Beacon Street @ Massachusetts Avenue (LOS F)

Unsignalized intersections would not be significantly impacted by the combination of projects.

Combination 4

Project Combination 4 includes two projects: Boston University Bridge and the Longfellow Bridge.

Morning Peak Hour

Level of Service would be reduced from existing conditions at seven signalized intersections and one unsignalized intersections during the morning peak hour. Of the seven signalized intersections, three would operate at LOS E or LOS F. The unsignalized intersection would operate at LOS E.

None of the intersections (signalized or unsignalized) would operate at an unacceptable level of service because of the combination of projects during the morning peak hour.

Afternoon Peak Hour

Level of Service would be reduced from existing conditions at ten signalized intersections during the afternoon peak hour. Of the ten signalized intersections, six would operate at LOS E or LOS F.



The analysis results show that only the signalized intersection of Beacon Street and Massachusetts Avenue would operate at LOS F during the afternoon peak hour as a result of the combination of projects.

Combination 5

Project Combination 5 includes four projects: Longfellow Bridge, River Street Bridge, Bowker Interchange - Phase II, and Western Avenue Bridge.

Morning Peak Hour

Level of Service would be reduced from 2012 No-Build conditions at eleven signalized intersections and one unsignalized intersection during the morning peak hour. Of the eleven signalized intersections, eight would operate at LOS E or LOS F. The unsignalized intersection would operate at LOS F.

The analysis results show that the following seven signalized intersections would operate at unacceptable levels of service because of the combination of projects:

- Memorial Drive at JFK Street (LOS F)
- Western Avenue at Soldiers Field Road EB off-ramp (LOS F)
- Western Avenue at Memorial Drive (LOS F)
- River Street at Memorial Drive (LOS F)
- Boston University Bridge at Commonwealth Avenue (LOS F)
- Memorial Drive EB Ramps at Massachusetts Avenue (LOS E)
- Beacon Street at Massachusetts Avenue (LOS E)

None of the unsignalized intersections would operate at an unacceptable level of service due to the combination of projects.



It should be noted that the signalized intersections of Memorial Drive at JFK Street and River Street at Memorial Drive are expected to operate at LOS F during No-Build conditions. Even though these intersections operate at LOS F during No-Build conditions, the combination of projects significantly affects these two intersections because the vehicle delay associated with the combination of projects is expected to be significantly greater than the vehicle delay associated with No-Build condition.

Afternoon Peak Hour

Level of Service would be reduced from 2012 No-Build conditions at eleven signalized intersections during the afternoon peak hour. Of the eleven signalized intersections, six would operate at LOS E or LOS F.

The following six signalized intersections would operate at unacceptable levels of service due to the combination of projects:

- Memorial Drive at JFK Street (LOS F)
- Cambridge Street at Soldiers Field Road EB on-ramp (LOS F)
- River Street at Memorial Drive (LOS F)
- Memorial Drive WB Ramps at Massachusetts Avenue (LOS F)
- Memorial Drive EB Ramps at Massachusetts Avenue (LOS F)
- Beacon Street at Massachusetts Avenue (LOS F)

None of the unsignalized intersections would operate at an unacceptable level of service due to the combination of projects.

As with the morning peak hour, it should be noted that the signalized intersections of Memorial Drive at JFK Street and River Street at Memorial Drive are expected to operate at LOS F during No-Build



conditions. Again, though these intersections operate at LOS F during No-Build conditions, the combination of projects would significantly affect these two intersections because the vehicle delay associated with the combination of projects is expected to be significantly greater than the vehicle delay associated with No-Build conditions.

Combination 6

Project Combination 6 includes three projects: Longfellow Bridge, Bowker Interchange - Phase II, and Storrow Drive Tunnels.

Morning Peak Hour

Level of Service would be reduced from 2012 No-Build conditions at eight signalized intersections and two unsignalized intersections during the morning peak hour. Of the eight signalized intersections, five would operate at LOS E or LOS F. One unsignalized intersections would operate at LOS E and the other would operate at LOS F.

The analysis results show that the following two signalized intersections would operate at an unacceptable level of service on account of the project combination:

- Western Avenue at Soldiers Field Road EB off-ramp (LOS F)
- River Street at Memorial Drive (LOS F)

The unsignalized intersection of the Longfellow Bridge inbound and the Memorial Drive ramps would operate at unacceptable levels of service due to the combination of projects.

It should be noted that the signalized intersection of River Street and Memorial Drive is expected to operate at LOS F during No-Build conditions. Even though this intersection would operate at LOS F during No-Build conditions, the combination of projects would significantly affect



this intersection because the vehicle delay associated with the combination is expected to be significantly greater than the vehicle delay associated with the No-Build condition.

Afternoon Peak Hour

Level of Service would be reduced from 2012 No-Build conditions at thirteen signalized intersections during the afternoon peak hour. Of the thirteen signalized intersections, nine would operate at LOS E or LOS F.

The analysis results show that the following two signalized intersections would operate at an unacceptable level of service because of the combination of projects:

- Western Avenue at Soldiers Field Road EB off-ramp (LOS E)
- Beacon Street at Massachusetts Avenue (LOS F)

None of the unsignalized intersections would operate at an unacceptable level of service due to the combination of projects.

Combination 7

Project Combination 7 includes five projects: Bowker Interchange - Phase II, Storrow Drive Tunnel, Reid Overpass, Eliot Bridge, and Larz Anderson Bridge.

Morning Peak Hour

Level of Service would be reduced from 2012 No-Build conditions at eight signalized intersections and two unsignalized intersections during the morning peak hour. Of the eight signalized intersections, six would operate at LOS E or LOS F. One unsignalized intersections would operate at LOS E and the other would operate at LOS F.



The analysis results show that the following four signalized intersections would operate at unacceptable levels of service due to the combination of projects:

- Memorial Drive at JFK Street (LOS F)
- Western Avenue at Soldiers Field Road EB off-ramp (LOS F)
- Cambridge Street at Soldiers Field Road EB on-ramp (LOS F)
- River Street at Memorial Drive (LOS F)

The following two unsignalized intersection would operate at unacceptable levels of service due to the combination of projects:

- Longfellow Bridge inbound @ Memorial Drive EB/WB Ramp (LOS F)
- Longfellow Bridge outbound at Storrow Dr. WB off-ramp (LOS E)

It should be noted that the signalized intersections of Memorial Drive at JFK Street and River Street at Memorial Drive are expected to operate at LOS F during No-Build conditions. Even though these intersections operate at LOS F during No-Build conditions, the combination of projects would significantly affect these two intersections because the vehicle delay associated with the combination of projects is expected to be significantly greater than the vehicle delay associated with No-Build conditions.

Afternoon Peak Hour

Level of Service would be reduced from 2012 No-Build conditions at twelve signalized intersections during the afternoon peak hour. Of the twelve signalized intersections, nine would operate at LOS E or LOS F.



The analysis results show that the following five signalized intersections would operate at an unacceptable level of service on account of the combination of projects:

- Memorial Drive at JFK Street (LOS F)
- Western Avenue at Soldiers Field Road EB off-ramp (LOS E)
- Western Avenue at Memorial Drive (LOS F)
- Cambridge Street at Soldiers Field Road EB on-ramp (LOS F)
- Beacon Street at Massachusetts Avenue (LOS F)

It should be noted that the signalized intersection of River Street and Memorial Drive is expected to operate at LOS F during No-Build conditions. Even though this intersection would operate at LOS F during No-Build conditions, the combination of projects would significantly affect the intersection because the vehicle delay associated with the combination of projects is expected to be significantly greater than the vehicle delay associated with the No-Build condition.

The unsignalized intersection of Longfellow Bridge inbound and the Memorial Drive ramps currently operates at LOS F and is expected to operate at LOS F during the No-Build conditions. The combination of projects is considered to significantly affect the intersection because the vehicle delay associated with the combination of projects is expected to be significantly greater than the vehicle delay associated with the No-Build condition.

Combination 8

Project Combination 8 includes four projects: Storrow Drive Tunnels, Reid Overpass, Eliot Bridge, and Larz Anderson Bridge.



Morning Peak Hour

Level of Service would be reduced from 2012 No-Build conditions at five signalized intersections and one unsignalized intersections during the morning peak hour. Of the five signalized intersections, three would operate at LOS E or LOS F. The unsignalized intersections would operate at LOS E.

The analysis results show that the following three signalized intersections would operate at an unacceptable level of service because of the combination of projects:

- Memorial Drive at JFK Street (LOS F)
- Cambridge Street at the Turnpike Ramps (LOS E)
- River Street at Memorial Drive (LOS F)

None of the unsignalized intersections would operate at an unacceptable level of service due to the combination of projects.

It should be noted that the signalized intersections of Memorial Drive at JFK Street and River Street at Memorial Drive are expected to operate at LOS E and LOS F, respectively, during No-Build conditions. Even though these intersections operate at LOS E and LOS F during No-Build conditions, the combination of projects would significantly affect these two intersections because the vehicle delay associated with the combination of projects is expected to be significantly greater than the vehicle delay associated with No-Build conditions.

Afternoon Peak Hour

Level of Service would be reduced from 2012 No-Build conditions at eleven signalized intersections during the afternoon peak hour. Of the eleven signalized intersections, eight would operate at LOS E or LOS F.



The analysis results show that only the signalized intersection of Western Avenue and Memorial Drive would operate at an unacceptable level of service due to the combination of projects.

The unsignalized intersection of Longfellow Bridge inbound and the Memorial Drive ramps currently operates at LOS F and is expected to operate at LOS F during 2012 No-Build conditions. The combination of projects would significantly affect this intersection because the vehicle delay associated with the combination of projects is expected to be significantly greater than the vehicle delay associated with the No-Build condition.

Combination 9

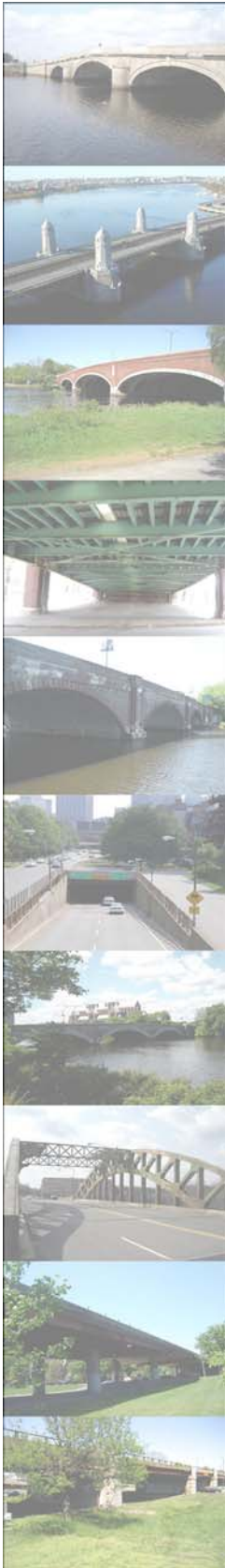
Project Combination 9 includes four projects: Longfellow Bridge, Bowker Interchange - Phase II, Western Avenue Bridge, and Storrow Drive Tunnels.

Morning Peak Hour

Level of Service would be reduced from 2012 No-Build conditions at nine signalized intersections and two unsignalized intersections during the morning peak hour. Of the nine signalized intersections, six would operate at LOS E or LOS F. Both unsignalized intersections would operate at LOS F.

The analysis results show that the following five signalized intersections would operate at an unacceptable level of service because of the combination of projects:

- Memorial Drive at JFK Street (LOS F)
- Western Avenue at Soldiers Field Road EB off-ramp (LOS F)
- River Street at Memorial Drive (LOS F)



- Boston University Bridge at Commonwealth Avenue (LOS F)
- Beacon Street at Massachusetts Avenue (LOS E)

None of the unsignalized intersections would operate at an unacceptable level of service due to the combination of projects.

It should be noted that the signalized intersections of Memorial Drive at JFK Street and River Street at Memorial Drive are expected to operate at LOS F during No-Build conditions. Even though these intersections operate at LOS F during No-Build conditions, the combination of projects would significantly affect these two intersections because the vehicle delay associated with the combination of projects is expected to be significantly greater than the vehicle delay associated with No-Build condition.

Afternoon Peak Hour

Level of Service would be reduced from 2012 No-Build conditions at thirteen signalized intersections during the afternoon peak hour. Of the thirteen signalized intersections, eight would operate at LOS E or LOS F.

The analysis results show that the following five signalized intersections would operate at unacceptable levels of service due to the combination of projects:

- Memorial Drive at JFK Street (LOS F)
- Boston University Bridge at Commonwealth Avenue (LOS F)
- Memorial Drive WB Ramps at Massachusetts Avenue (LOS F)
- Memorial Drive EB Ramps at Massachusetts Avenue (LOS E)
- Beacon Street at Massachusetts Avenue (LOS F)



None of the unsignalized intersections would operate at an unacceptable level of service due to the combination of projects.

As with the morning peak hour, it should be noted that the signalized intersection of Memorial Drive at JFK Street is expected to operate at LOS F during No-Build conditions. Even though this intersection would operate at LOS F during No-Build conditions, the combination of projects would significantly affect the intersection because the vehicle delay associated with the combination of projects is expected to be significantly greater than the vehicle delay associated with No-Build conditions.

Combination Analysis Summary

The results of the combination analysis stated above can be summarized by the following points:

- Level of service is unacceptable by the combination of projects in 58 out of 672 cases analyzed (42 intersections x 2 time periods (AM and PM peak hour) x 8 combinations = 672 cases). See Table D-1 in Appendix D.
- These 58 cases of unacceptable LOS occur at 14 intersections. Therefore, 33% (14/42) of the intersections experience unacceptable traffic operations (LOS E or F) due to at least one of the project combinations. See Figure D2, D3, and D4 in Appendix D.
- All 14 intersections affected are located at the termini of a bridge crossing the Charles River.



- Out of the 58 cases, 12 cases occur at the termini of a bridge that is under construction, while the remaining 46 cases are located at the termini of a bridge at which no construction is occurring.
- The maximum number of intersections with unacceptable traffic operations affected during a peak hour during any one combination is 7. Therefore, a maximum of 17% (7/42) of the intersections are affected during the peak hour of any one combination.

Mitigation Measures

The following section will discuss various mitigation measures that could be applied at intersections which would operate at an unacceptable level of service due to a project combination.

Signalized Intersection Improvements

The first mitigation measure explored for signalized intersections was signal timing changes. Retiming a signal to better serve the traffic volume associated with the project combination can often improve intersection level of service greatly.

Along with signal timing changes, lane use changes were investigated to improve intersection operations. An existing roadway approach with two lanes may have a shared left turn and through lane and a shared right turn and through lane. If a large increase in left turn traffic is expected, it may be necessary to change the lane use of the shared left turn and through lane to an exclusive left turn lane. This change would provide the left turning vehicles with queuing space and it would also remove through vehicles from the left turn queue.

Traffic volumes, signal timing, and lane use changes may also require new signal phasing. A low volume left turn movement under exist-



ing conditions may operate as a permitted movement. If the volume of opposing through vehicles is greatly increased, the left turn movement may need to operate as a protected left turn to allow vehicles an opportunity to turn.

Most intersections within the study area which would have unacceptable operations because of the project combinations are located in fully developed areas or are located in recreation areas. For these reasons adding lanes to the intersection approaches was investigated but often it was not considered a practical mitigation measure.

Unsignalized Intersection Improvements

Fewer options are typically available to mitigate project effects at unsignalized intersections. The mitigation measure investigated first by this project was installation of traffic signal equipment.

Mitigation Analysis

The following section presents the results of the Combination Analysis with mitigation measures in place.

Combinations 1 and 2

The intersections affected by combination 1 and 2 are identical, therefore, one set of mitigation measures has been developed to address both combinations. Signal retiming was examined at one intersection during the morning peak hour and at three intersections during the afternoon peak hour. Traffic signal installation was examined at two unsignalized intersection locations.

Signalized Intersections

Signal timing changes were analyzed at the intersection of Longfellow Bridge inbound and Charles Street. Signal operations could be im-



proved from LOS F to LOS D during the morning peak hour with signal timing changes. The intersection of Cambridge Street WB and Charles Street should also be retimed because it is a closely spaced signalized intersection operating in coordination with the Longfellow Bridge inbound roadway at Charles Street intersection.

Signal operations could be improved through signal timing changes during the afternoon peak hour at the following three intersections:

- Memorial Drive EB ramps at Massachusetts Avenue (LOS F to LOS D)
- Beacon Street at Massachusetts Avenue (LOS F to LOS D)
- Longfellow Bridge inbound at Charles Street (LOS E to LOS D)

It should be noted that the intersections of the Memorial Drive ramps with Massachusetts Avenue operate with one traffic signal controller though there are two intersections. It is possible that signal timing modifications made to improve level of service at one intersection could reduce level of service at the other. Throughout this project signal timing changes at these intersections were monitored to ensure that the intersection operating at an acceptable level of service remained at LOS D or better.

Unsignalized Intersections

Traffic operations at the unsignalized intersection of the Longfellow Bridge inbound and the Memorial Drive ramps could be improved during both peak hours with the installation of traffic signal equipment. Level of Service would improve during the morning peak hour from LOS F to LOS C and from LOS F to LOS D during the afternoon peak hour.



Traffic operations at the unsignalized intersection of the Longfellow Bridge outbound and the Storrow Drive Westbound off-ramp could also be improved with the installation of traffic signal equipment. Level of Service would remain unchanged from unsignalized conditions during the morning peak hour, but could improve from LOS E to LOS B during the afternoon peak hour. Signal operations at this intersection should also be coordinated with the Cambridge Street WB at Charles Street and the Longfellow Bridge inbound at Charles Street intersections because of its close proximity to these intersections.

Combination 3

Signal timing changes are proposed at one intersection during the morning peak hour and at two intersections during the afternoon peak hour. Installation of traffic signals was examined at one unsignalized intersection and the traffic signal installations examined in Combination 1 and 2 were assumed to continue through Combination 3.

Signalized Intersections

Traffic operations at the intersection of Memorial Drive EB ramps and Massachusetts Avenue could be improved from LOS E to LOS C during the morning peak hour and from LOS F to LOS E during the afternoon peak hour with signal timing changes. At the intersections of Beacon Street and Massachusetts Avenue, signal timing changes could improve traffic operations from LOS F to LOS E during the afternoon peak hour. Though vehicle delay would be reduced two of the three signalized intersections would continue to operate at unacceptable levels of service.



Unsignalized Intersections

Traffic signal installation was examined at the intersection of Longfellow Bridge outbound and the Memorial Drive Ramp. The installation could improve operations from LOS E to LOS B during the morning peak hour and LOS C to LOS A during the afternoon peak hour. The traffic signals examined during Combinations 1 and 2 were maintained under Combination 3. Both intersections would operate at LOS C or better during both peak hours.

Combination 4

The intersection of Beacon Street and Massachusetts Avenue would be significantly affected by the combination of projects during the afternoon peak hour. Traffic signal timing modifications were examined and these modifications could improve intersection level of service from LOS F to LOS D.

Combination 5

Signal timing changes were examined at seven intersections during the morning peak hour and at six intersections during the afternoon peak hour.

Signalized Intersections

Signal timing modifications could improve level of service at the following five intersections during the morning peak hour:

- Western Avenue at Soldiers Field Road EB off-ramp (LOS F to LOS D)
- Western Avenue at Memorial Drive (LOS F to LOS D)
- Boston University Bridge at Commonwealth Avenue (LOS F to LOS C)
- Memorial Drive EB Ramps at Massachusetts Avenue (LOS E to LOS C)
- Beacon Street at Massachusetts Avenue (LOS E to LOS D)



Mitigation measures examined would not improve intersection level of service to acceptable levels at the following two intersections during the morning peak hour:

- Memorial Drive at JFK Street (LOS F, 144 seconds of delay)
- River Street at Memorial Drive (LOS F, 250 seconds of delay)

Level of service could be improved to acceptable levels at the following three intersections through signal timing adjustments during the afternoon peak hour:

- Memorial Drive at JFK Street (LOS F to LOS D)
- Cambridge Street at Soldiers Field Road EB on-ramp (LOS F to LOS D)
- Memorial Drive EB Ramps at Massachusetts Avenue (LOS F to LOS D)

Mitigation measures examined would not improve intersection level of service to acceptable levels at the following three intersections during the afternoon peak hour:

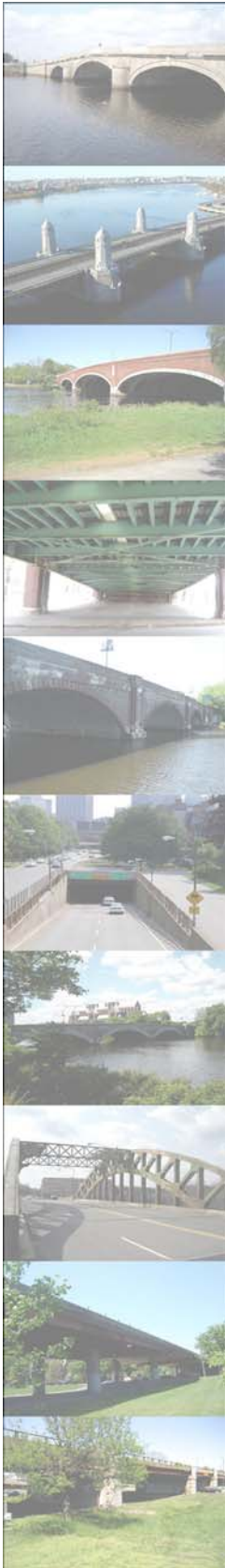
- River Street at Memorial Drive (LOS F, 144 seconds of delay)
- Memorial Drive WB Ramps at Massachusetts Avenue (LOS E, 67 seconds of delay)
- Beacon Street at Massachusetts Avenue (LOS E, 64 seconds of delay)

Unsignalized Intersections

The unsignalized intersections within the study area would not be significantly effected by Combination 5 during either peak hour.

Combination 6

Signal timing changes were investigated at two intersections during both of the peak hours. Signal installation was investigated at one unsignalized intersection.



Signalized Intersections

Signal timing changes could improve intersection level of service at the intersection of Western Avenue and Soldiers Field Road EB off-ramp from LOS F to LOS D during the morning peak hour and LOS E to LOS D during the afternoon peak hour. Intersection level of service could be improved from LOS F to LOS D at the intersection of Beacon Street and Massachusetts Avenue during the afternoon peak hour.

Intersection level of service could not be improved to acceptable levels at the intersection of River Street and Memorial Drive during the morning peak hour (LOS F, 209 seconds of delay).

Unsignalized Intersections

Signal installation at the intersection of the Longfellow Bridge inbound roadway and the Memorial Drive Ramp could improve level of service from LOS F to LOS C during the morning peak hour and LOS F to LOS B during the afternoon peak hour.

Combination 7

Signal timing modifications were examined at four intersections during the morning peak hour and five intersections during the afternoon peak hour. Traffic signal installation was examined at 2 unsignalized intersections.

Signalized Intersections

The mitigation measures investigated would be ineffective at reducing intersection level of service at all four intersections during the morning peak hour. The following intersections would continue to operate at unacceptable levels of service:

- Memorial Drive at JFK Street (LOS F, 126 seconds of delay)



- Western Avenue at Soldiers Field Road EB off-ramp (LOS E, 65 seconds of delay)
- Cambridge Street at soldiers Field Road EB on-ramp (LOS F, 105 seconds of delay)
- River Street at Memorial Drive (LOS F, 195 seconds of delay)

During the afternoon peak hour, signal timing changes could improve intersection level of service to acceptable levels at the following intersections:

- Memorial Drive and JFK Street (LOS F to LOS D)
- Cambridge Street at Soldiers Field Road EB on-ramp (LOS F to LOS D)
- Beacon Street at Massachusetts Avenue (LOS F to LOS D)

The mitigation measures examined could improve intersection operations to borderline acceptable levels of service at the following two intersections:

- Western Avenue at Soldiers Field Road EB off-ramp (LOS E, 57.2 seconds of delay)
- Western Avenue at Memorial Drive (LOS E, 57.5 seconds of delay)

Unsignalized Intersections

Traffic signal installation could improve level of service at the following two unsignalized intersections:

- Longfellow Bridge inbound at the Memorial Drive ramp (AM: LOS F to LOS C, PM: LOS F to LOS C)
- Longfellow Bridge outbound at the Storrow Drive WB off-ramp (AM: LOS E to LOS B, PM: LOS D to LOS B)



Combination 8

Traffic signal timing modifications were examined at three intersections during the morning peak hour and one intersection during the afternoon peak hour. Traffic signal installation was examined at one unsignalized intersection.

Signalized Intersections

The mitigation measures examined were unable to improve intersection level of service to acceptable levels at the following three intersections during the morning peak hour:

- Memorial Drive at JFK Street (LOS F, 63 seconds of delay)
- Cambridge Street at turnpike ramps (LOS E, 66 seconds of delay)
- River Street at Memorial Drive (LOS F, 104 seconds of delay)

The same holds true for the following intersection during the afternoon peak hour:

- Western Avenue at Memorial Drive (LOS E, 60 seconds of delay)

Unsignalized Intersections

Traffic signal installation at the intersection of the Longfellow Bridge inbound and the Memorial Drive ramps would improve level of service from LOS E to LOS B during the morning peak hour and LOS F to LOS C during the afternoon peak hour.

Combination 9

Traffic signal timing changes were examined at five intersections during both the morning and afternoon peak hours.

Signalized Intersections

Level of service could be improved to acceptable levels with signal timing modifications at the following three signalized intersection:



- Western Avenue at Soldiers Field Road EB off-Ramp (LOS F to LOS C)
- Boston University Bridge at Commonwealth Avenue (LOS F to LOS C)
- Beacon Street at Massachusetts Avenue (LOS E to LOS D)

Intersection level of service could not be improved to acceptable levels through the mitigation measures examined at the following two locations:

- Memorial Drive at JFK Street (LOS F, 117 seconds of delay)
- River Street at Memorial Drive (LOS F, 221 seconds of delay)

During the afternoon peak hour, level of service could be improved to acceptable levels through traffic signal timing modifications at the following three intersections:

- Memorial Drive at JFK Street (LOS F to LOS D)
- Boston University Bridge at Commonwealth Avenue (LOS F to LOS C)
- Memorial Drive EB Ramps at Massachusetts Avenue (LOS E to LOS C)

Level of service could not be improved to acceptable levels through the mitigation measures examined at the following two intersections:

- Memorial Drive WB Ramps at Massachusetts Avenue (LOS E, 67 seconds of delay)
- Beacon Street at Massachusetts Avenue (LOS E, 68 seconds of delay)

Unsignalized Intersections

The unsignalized intersections within the study area would not be significantly effected by Combination 9 during either peak hour.



Mitigation Analysis - Summary

The following provides a summary of intersections experiencing unacceptable Level of Service (LOS) operations (defined as LOS E or F) as a result of the various project combinations with mitigation.

- Of the 58 previously identified unacceptable intersection Level of Service occurrences, 36 have been mitigated to LOS D or better. The remaining 22 occurrences continue to operate at LOS E or F, although the delay times have been reduced (see Table B-1 Appendix B).
- These remaining 22 cases of unacceptable LOS occur at 9 intersections, therefore 5 of the 14 intersections experiencing unacceptable levels of service due to the project combinations have been mitigated completely.
- Twelve of these remaining 22 cases occur during the AM peak hour while ten occur during the PM peak hour (see Figure B2 and B4 in Appendix B).
- The 9 intersections that continue to experience unacceptable traffic operations due to at least one project combination are all located at the termini of a bridge crossing the Charles River (see Figure B2 Appendix B).
- Of the 22 cases of unacceptable level of service, 6 cases occur at the termini of a bridge that is under construction, while the remaining 16 cases are located at the termini of a bridge at which no construction is occurring.
- The maximum number of intersections with unacceptable traffic operations affected during a peak hour during any one combination is 6.



Therefore, approximately 14% (6/42) of the intersections are affected during any one combination.

- The two worst periods of traffic operation occur during a 30 month period spanning 2 combinations commencing in 2012 and during a 12 month period spanning 1 combination commencing in 2015. During the 30 month period, two intersections would operate at LOS F during the morning peak hour and two intersections would operate at LOS E and one intersection would operate at LOS F for 26 of the 30 months during the afternoon peak hour. During the 12 month period, one intersection would operate at LOS E and three intersections would operate at LOS F during the morning peak hour. During the afternoon peak hour, two intersections would operate at LOS E (see Figure B3 in Appendix B).
- During these two time periods, the 14 occurrences occur at seven intersections within the basin, of which four are located on Memorial Drive, two on Soldiers Field Road, and one on Massachusetts Avenue. From a global point of view, and an appreciation for the amount and magnitude of the construction underway during these periods, these results are remarkable. It is not expected that an alternate schedule depicting different or modified concurrent rehabilitation projects would result in improved intersection operations.



Project Durations

Preparation of the synchronization schedule required certain assumptions pertaining to the anticipated consultant procurement, rehabilitation design, environmental permitting, and contractor procurement process durations. In addition to the paragraphs below, which contain a discussion of those assumptions, six months of float was added to account for delays or extensions.

Design Consultant Procurement

For the purposes of this Study, it was assumed that all design work would be performed by an independent design consultant, and not by the in-house staff of MassHighway or DCR. For those identified structures that do not currently have a design consultant under contract, it was assumed that selection of the design consultant would follow MassHighway's standard designer selection process. This process typically requires approximately eight months to complete and entails the following tasks:

- Issuing a Request for Response
- Short listing the highest ranked responses
- Soliciting Technical Proposals
- Interviewing short-listed candidates
- Selecting the designer using a designer selection committee

After selection, approximately four months are required to negotiate a final Scope of Services and accompanying fees. The synchronization study is therefore based on a twelve-month period for the selection of a design consultant and issuance of a Notice to Proceed.



Design and Permitting

The Study used design periods for the identified structures of twelve, eighteen, or twenty-four months depending on the level of complexity of the rehabilitation program.

The Study used environmental permitting periods of twelve months for the majority of the identified structures. A period of thirty six months was used for the more complex rehabilitation projects. Even though early coordination with the resource agencies is strongly recommended to begin upon initiation of the design, the actual permitting timeline was assumed to commence upon completion of the preliminary (25%) design submittal (at approximately 33% completion of the design phase timeline).

Contractor Procurement

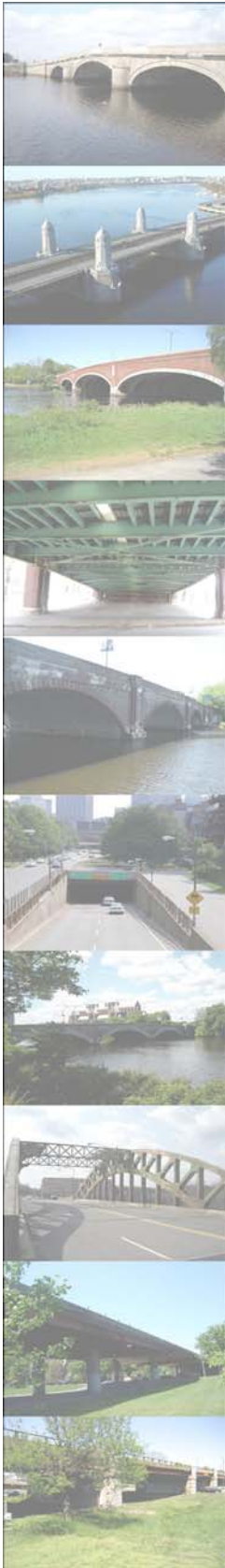
The bid phase and procurement of a contractor was assumed to require a two-month duration which would be concurrent with completion of the permitting process. This assumes that any Notice of Intent filings and issuance of any Order of Conditions are completed before letting.

Contractor Notice to Proceed

The execution of a construction contract and issuance of a Notice to Proceed was assumed to require two months after the bid opening. This duration is based upon typical timelines for projects in which MassHighway oversees construction.

Construction Durations

Estimated construction durations were obtained in two ways for this Study. First, for projects that are currently under design, the information provided by DCR typically included a recommended staging concept and



durations for each identified stage. This information was reviewed against the anticipated rehabilitation program to be undertaken for its reasonableness. As a result, the Study is based upon this information for all projects currently under design.

For those projects where no design efforts have been undertaken, an overall construction schedule was developed based upon a most probable rehabilitation program and the associated staging required. These Detail Schedules and there resulting construction durations can be found in Appendix J.



Study Limitations

This Study is intended to be a planning-level tool. The development of this Study is based primarily upon documentation made available to the BETA Team by other Agencies. No independent structural or traffic analyses, reviews, assessments, or field studies were conducted as part of this Study. Field observations did not include in-depth structural inspections, and were performed without the aid of any special equipment, lane closures, police details, or traffic management controls.

It was anticipated that the rehabilitation projects would be limited to the existing structures' footprints, and would not be designed to accommodate additional traffic volumes.

It is not the intent of this Study to determine the remaining service life of structures or the extent of rehabilitation necessary to ensure continued public safety.

Detailed structural evaluations to determine if a project can be delayed to meet with the suggested sequence depicted in the Synchronization Plan was not included as part of the Study.



Conclusions

This Final Report, which concludes Phase I of the Study, provides a planning-level synchronization schedule that minimizes, to the extent possible, traffic delays and congestion while maintaining public safety and convenience for the duration of the identified rehabilitation projects. The synchronization schedule identifies each project's anticipated duration from designer selection through completion of construction, and identifies the most logical combination of projects that may undergo concurrent construction. This schedule provides a logical roadmap for the rehabilitation of the twelve identified critical transportation assets within the Charles River Basin over the years to come.

Phase II of the Study is anticipated to include a regional analysis of the traffic impacts, as well as a public comment process. The Central Transportation Planning Staff (CTPS) has the ability to analyze the impacts of the proposed traffic re-assignments within the expanded regional transportation network. The results of that analysis can be used to confirm or adjust the Study's findings. Additionally, input gathered from major stakeholders and the general public can be incorporated into the Study to ensure that it is based upon the most appropriate data.

This schedule should be considered a dynamic document that can be periodically updated based upon the actual status, progress, commencement, and duration of each individual rehabilitation project. Proposed changes to the schedule of one individual project could be reviewed in relation to the overall Basin construction to determine if those changes would result in degradation of traffic operations. Finally, this schedule could also be utilized as an aid in determining the appropriate timing of design consultant procurement; contractor procurement; and even required annual capital improvement funding.